PRIVATE
DEPOSITORY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXV. *February* 10, 1865. No. 4.

THE Annual General Meeting of the Society, WARREN DE LA RUE, Esq., President, in the Chair.

Emmanuel Wilkins Jones, Esq., 13 Cowley Place, North Brixton;

Thomas Jones, Esq., 10 Dundas Terrace, Plumstead;

John Merrifield, Esq., Gascoyne Place, Plymouth; and

Joseph Maguire, Esq., 6 Wellington Place, Norwich,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Forty-fifth Annual General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1863	164	244	24	5	437	47	484
Since elected	3	28	...	...	...	3	...
Deceased	−7	−3	...	...	...	−1	...
Removals	3	−3	...	...	...	...	...
Expelled	...	−2	...	...	...	...	...
Dec. 31, 1864	163	264	24	5	456	49	505

Treasurer's Report of Receipts and Expenditure for the year ending December 31, 1864:—

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance of last year's accoont				353	4	1
By Dividend on £2100 Consols	30	11	8			
By ditto on £4300 New 3 per Cents	62	12	5			
By ditto on £2100 Consols	30	14	3			
By ditto on £4300 New 3 per Cents	65	16	3			
				189	14	7
On account of arrears of contributions ...	231	2	0			
136 contributions, 1863–4, 4–5	286	13	0			
6 compositions	123	18	0			
27 admission-fees	56	14	0			
28 first contributions	47	5	0			
				745	12	0
Sale of publications				98	2	2
Legacy of B. Botfield, Esq.				22	0	0
Admiralty for printing				68	0	0
				£1476	12	10

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:—						
Editor of Publications	60	0	0			
Assistant Secretary	100	0	0			
Commission on Collecting	36	0	0			
				196	0	0
Iuvestments:—						
Purchase of £81 14 4 New 3 per Cents	74	3	7			
Ditto £100 New 3 per Cents ...	89	10	0			
Ditto £100 New 3 per Cents ...	89	10	0			
Ditto £200 New 3 per Cents ...	177	15	0			
				430	18	7
Taxes:—						
Assessed and Income	6	2	8			
Parish Rates	11	16	0			
				17	18	8
Carried forward				£644	17	3

		£	s.	d.
Bills :—	Brought forward	644	17	3
Strangeways and Co., printers ...	£290 13 8			
J. Rumfitt, bookbinder	3 17 8			
J. Basire, engraver	48 3 9			
Woods, wood engraver	20 16 0			
Pearson, ditto	3 11 0			
Dangerfield, lithographer	5 10 0			
Turnor Fund—Maynard, Quaritch, &c.	15 2 6			
Elkington, Annual Dinner	5 19 0			
C. Frodsham, repair of clock	5 3 0			
Lee Fund—Mrs. Harris	15 0 0			
Harrison, account books	2 14 0			
Sun Fire Office Insurance	12 5 6			
		428	16	1
Miscellaneous items :—				
Books and parcels	5 18 6			
Postage of *Monthly Notices*, letters, &c.	33 15 6			
House expenses	23 0 8			
Expenses of evening meetings ...	13 13 0			
Waiters attending meetings	3 17 0			
Coals and Gas	16 14 3			
Sundry disbursements by Treasurer ...	15 14 5			
Payment out of the Turnor Fund ...	0 1 8			
Mrs. Jackson's annuity, 1 year ...	8 13 4			
		121	8	4
Charge on country cheque...		0	0	3
		£1195	1	11
Balance at Banker's		281	10	11
		£1476	12	10

S. C. Whitbread, Treasurer.

Auditors' Report.

We, the undersigned, having audited the accounts of the Royal Astronomical Society for the past year, have the pleasure to report that £430 18*s.* 7*d.* was invested in Government Stock, and that the balance at the Bankers on 31st December last was £281 10*s.* 11*d.*, as vouched by their pass-book. Also,

that the Stock possessed by the Society was then £2100 3 per Cents Consols and £4700 New 3 per Cents, representing dividents of £204 per annum.

HENRY PERIGAL, JUN.
JOSEPH BECK.

1 *February*, 1865.

The Treasurer's Report deals only with the monies actually received and disbursed by him. The following Revenue Account and Balance Sheet, which are made out in accordance with the plan adopted for the year 1863, show the exact position of the Society both as regards assets and liabilities:—

REVENUE ACCOUNT FOR THE YEAR 1864.

Dr.

	£ s. d.	£ s. d.
To Composition fund	... ...	126 0 0
Turnor fund	15 0 0	
Lee fund	3 5 6	
Mrs. Jackson	8 13 4	
		26 18 10
Rent	... ...	– – –
Editor	60 0 0	
Printing	193 8 6	
Engraving and lithographing ...	22 17 0	
Binding	7 17 8	
Assistant-Secretary	100 0 0	
Collection	36 0 0	
		420 3 2
Taxes	16 8 6	
Postage	33 15 6	
Parcels	5 18 6	
House Expenses	23 0 8	
Coals and gas	16 17 3	
Meetings	17 10 0	
Insurance	12 5 6	
Repairs	2 6 0	
Medal	10 10 0	
Sundries	27 4 8	
		165 16 7
Sums written off	37 16 0	
To Capital—increase	489 9 9	
		527 5 9
		£1266 4 4

	£ s. d.	Cr. £ s. d.
By New compositions		126 0 0
Composition fund—deaths		147 0 0
Admission fees		65 2 0
First year's contributions		61 19 0
Annual contributions		506 2 0
Legacies: Mr. Botfield		22 0 0
Dividends, January	30 11 8	
,, April	62 12 5	
,, July	30 14 3	
,, October	65 16 3	189 14 7
Sale of publications		97 11 0
By Investing under par		50 15 9
		1266 4 4

BALANCES, December 31, 1864.

Dr. £ s. d.		Cr. £ s. d.
– – –	Cash in hand.	
281 10 11	Banker's balance.	
	Proceeds of Turnor fund	81 18 8
	Proceeds of Lee fund	3 0 3
	Due to Mrs. Jackson	– – –
344 8 0	Annual contributions—arrears.	
	,, paid in advance	5 5 0
8 8 0	Admission fees—4 due	
2 9 6	Due for publications.	
	Reserve against sums due	65 0 0
2100 0 0	3 per Cent Consols at par.	
	,, Turnor fund	500 0 0
	,, Lee fund	110 0 0
4700 0 0	New 3 per Cents at par.	
	,, Jackson fund	300 0 0
	Sundry debts unpaid	83 9 6
21 0 0	2 medals in stock.	
– – –	Unsold publications.	
– – –	Books and instruments.	
	Composition fund ... £3423 0 0	
	Net capital 2886 3 0	6309 3 0
7457 16 5		7457 16 5

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	18	XI.	197	XXI. (together).	103
I. Part 2	59	XII.	204	XXII.	199
II. Part 1	77	XIII.	218	XXIII.	191
II. Part 2	41	XIV.	405	XXIV.	202
III. Part 1	94	XV.	187	XXV.	211
III. Part 2	113	XVI.	210	XXVI.	219
IV. Part 1	113	XVII.	188	XXVII.	477
IV. Part 2	125	XVIII.	188	XXVIII.	434
V.	140	XIX.	202	XXIX.	465
VI.	161	XX.	194	XXX.	227
VII.	183	XXI. Part 1 (separate).	316	XXXI.	209
VIII.	170			XXXII.	253
IX.	175	XXI. Part 2 (separate).	100		
X.	188				

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1.
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.

4. $3\frac{7}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.
26. Dipping needle.
27. Intensity needle.
28. Ditto ditto.
29. Box of magnetic apparatus.
30. Hassler's reflecting circle, with artificial horizon roof.
31. Box sextant and $2\frac{1}{4}$-inch glass plane artificial horizon.
32. Plane speculum artificial horizon and stand.
33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.
34. Artificial horizon roof and trough.
35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.
36. A pentagraph.
37. A noddy.
38. A small Galilean telescope, with the object lens of rock-crystal.
39. Six levels, various.
40. 18-inch celestial globe.
41. Varley stand for telescope.
42. Thermometer.
43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Beaufoy* clock, No. 1, to Dr. Booth.
The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument, No. 1, to Mr. Lassell.
Ditto ditto No. 2, to Mr. De La Rue.
Ditto ditto No. 5, to Mr. Birt.
Ditto ditto No. 6, to Rev. J. Cape.
Ditto ditto No. 8, to Rev. C. Pritchard.
Ditto ditto No. 9, to Mr. Lockyer.
Ditto ditto No. 19, to Mr. Dayman.
Ditto ditto No. 25, to Mr. Dayman.
Ditto ditto No. 41, to Rev. C. Pritchard.
Ditto ditto No. 43, to Mr. Huggins.
The 6-inch circular protractor, to Mr. Birt.

The Volume of the Memoirs.

The contents are as follows :—

I. "Geocentric North Polar Distances of the Moon and Moon-culminating Stars, reduced from Observations made by Sir Thomas Maclear with the Transit Circle at the Cape of Good Hope, in the years 1856–61." The value of these observations requires no comment. It is proper to add that, through the intervention of the Astronomer Royal, the cost of printing this Memoir is defrayed by the British Government.

II. "Proper Motions of the Stars of the Greenwich Seven-year Catalogue not included in the Twelve and Six-year Catalogues, &c." By E. J. Stone, Esq. M.A., First Assistant of the Royal Observatory, Greenwich.

III. "A Determination of the Sun's Mean Equatoreal Horizontal Parallax."

This Memoir, also by Mr. Stone, is an extension or completion of a Paper by the same author in the *Monthly Notices* wherein he obtained the Sun's Parallax by comparison of observations made during the opposition of *Mars*, at the Royal Observatory, Greenwich, and the Government Observatory, Williamstown. In the present communication the comparison is further extended by the introduction of observations made at the Cape of Good Hope. The result does not materially modify that previously obtained from the observations of the two other Observatories alone. The ultimate conclusion is a mean equatoreal horizontal parallax $=8''\cdot943$. A notable feature in this Memoir is the care with which the probable error and final weight of the result is obtained. It may be interesting here to give a summary of all the values of the Sun's Parallax recently obtained by various methods of investigation.

By Bessel ...	(Transit of *Venus*) ...	$8''\cdot578$
Hansen	(Moon's Parallactic Equation)	$8''\cdot916$
Leverrier ...	(Solar Tables) ...	$8''\cdot950$
Winnecke ...	(Opposition of *Mars*) ...	$8''\cdot964$
Stone ...	(ditto) ...	$8''\cdot943$

so that the first decimal ·9 may be considered established.

IV. "On the Methods of Determining heights in the Trigonometrical Survey of India." By Lt.-Col. Walker, R.E.

This Memoir is worthy of attention, not only on account of the information which it contains relative to certain geodetical operations in India, but especially so from the remarkable effects of the physical circumstances of a level tropical country, on the refration of light near to its surface. The precautions also which have been adopted to secure accuracy under anomalous circumstances, will be read with interest, more especially as now they have been so clearly pointed out, modifications of these anomalies to a greater or less extent, will be anticipated in future surveys of other countries less subject to solar and terrestrial radiation.

V. "On the so-called Willow-leaf Markings on the Sun."

In this Memoir Mr. De La Rue cites further confirmation and independent authority in the person of Dr. Müller certainly, and partially in the person of Padre Secchi, for the existence of the peculiar markings on the visible part of the sun's photosphere originally indicated by Mr. Naysmith. That certain bright points, thickly scattered over the sun's disk, are at least occasionally visible, has been confirmed by the Greenwich observers, Messrs. Stone, Carpenter, and Dunkin (the last-named gentleman having recorded their number in a given angular space). For an acknowledged solution of this amicable controversy we must wait in patience.

VI. "On the Probable Error of Meridional Transit-observation, by the 'Eye and Ear' and by the 'Chronographic Method.'" By E. Dunkin, Esq.

It is well known to the Members of the Royal Astronomical Society that of late years many valuable contributions have, with a view to their more speedy publication, been printed in the *Monthly Notices* alone, which at other times would have found a place in the more formal volumes of the *Memoirs*. Such unquestionably is the case with the valuable paper contributed under the title above, by Mr. Dunkin, one of the assistants at the Royal Observatory. It contains the first published and formal discussion of the relative accuracy of the old eye-and-ear observation, and the more modern method of recording the time of a transit through the intervention of contact and electricity. For this investigation Mr. Dunkin has availed himself of the advantages of access to the Greenwich observations carried on by both methods, through a series of years, and by observers of admitted skill. The result is greatly in favour of the electric method. For whereas, "the probable error of a Greenwich result of right ascension in the year 1853, determined from 'eye-and-ear' transits is $0^s{\cdot}048$; the corre-

sponding probable error, resulting from 'chronographic' transits, in the year 1857 is $\pm 0^s.034$."

VII. "Ancient Chinese Astronomical Observations."

Mr. Williams, the Assistant-Secretary of the Society, has communicated to the Society* an account of 36 Solar Eclipses recorded in an ancient Chinese historical work, called *Chun Tseu*, written by Kung Foo Tsze, or Confucius, as having been observed in China between the years 720 and 495 B.C. To these he has subsequently added 56 other Eclipses, also Solar, mentioned in an esteemed historical work, called *Tung Keen Kang Muh*, as having occurred between the years 481 B.C. and the Christian era. It is worthy of remark that he has hitherto met with no record of a Lunar Eclipse, and also that in three Chinese historical works in his possession the Solar Eclipses just mentioned are recorded in as nearly as possible the same words. Mr. Williams proposes continuing this list of Eclipses as far as the works mentioned will allow; and as records of Comets and other extraordinary appearances in the heavens are also common, he hopes on some future occasion to be able to lay a list of these also before the Society.

Obituary.

The Society has to regret the loss by death of the following Fellows and Associate:—

Fellows.—Archdeacon Burney.
R. Graham, Esq.
Capt. J. Higgens.
W. C. Mylne, Esq.
Dr. H. Neill.
W. H. Palmer, Esq.
Rev. S. H. Pinckney.
Maj.-Gen. Portlock.
Rev. C. Strong.

Associate.—M. F. W. von Struve.

Robert Graham was born in London in the year 1779. His parents died when he was not more than thirteen years of age, leaving him entirely dependent upon his own resources. By industry and close attention to his business, as a silk-manufacturer, he realised a considerable fortune. He joined

* *Monthly Notices*, vol. xxiv. pp. 39 and 185.

the Mathematical Society in 1807, in which he was much respected as an active and intelligent member, and during the later years of the separate existence of that Society, he held the office of Treasurer. At the junction of the two Societies in 1845, he became a Fellow of the Royal Astronomical Society, and to the last was a frequent attendant at the evening meetings. He died December 16, 1864, in the 86th year of his age.

We are indebted to Admiral Smyth for the following obituary notice of CAPTAIN HIGGENS, extracted from a provincial newspaper:—

"It is with the sincerest regret that we this week record the death of our fellow-townsman Captain Higgens, which took place on Saturday night last. This regret will be deeply shared by all who knew him. His amiable and unassuming deportment, his varied and extensive information, and his ardent love of scientific pursuits, secured to him a number of friends who appreciated his high intellectual and moral worth, and were deeply attached to him. His favourite study was astronomy, of which science he had an extensive and very practical knowledge. In consequence of original and valuable astronomical observations which he had submitted to the notice of some of our leading astronomers, he was induced a short time ago to allow himself to be put in nomination as a Fellow of the Royal Astronomical Society. To the distinction he was most cordially welcomed by our former townsman (Admiral Smyth) and many other eminent astronomers.

"Captain Higgens went out to India in the year 1828, in the H. E. I. C. ship Sir David Scott. After a service of thirty-two years he retired in 1860. His services were highly appreciated, as shown by the several valuable testimonials presented to him by officers who had served under him; and on two occasions he received letters of thanks from the supreme government of India. In the year 1830 he joined Government exploring expeditions in Australia, and was engaged in the arduous work for a year and a half. As a naval commander he had seen hard service in India, and had survived many severe attacks of illness in that ungenial climate. With a constitution somewhat enfeebled he was sent home to England. He settled in Bedford, and here (surrounded by his loving family, with leisure to instruct the younger members, and at the same time to follow his scientific pursuits, and to enjoy the society of many deeply attached friends), he was anticipating a period of honourable retirement, but in the midst of his useful retirement he has been removed from us. Six days before his death he was seized with double pneumonia, brought on by exposure to the cold, and his already

enfeebled system could not grapple with the terrific disease. In accordance with his own wish his funeral took place within three days of his death, and his remains were conveyed to their final resting-place in the cemetery amidst the deep respect shown in a marked manner by the large attendance at the funeral."

Dr. Hugh Neill was born in the year 1806. He received his diploma from the Royal College of Surgeons, Edinburgh, in 1827, and was shortly after appointed surgeon to the steam ship Duke of York, chartered by the Government to convey mails and passengers to and from Spain, Portugal, and the ports of the Mediterranean. He commenced practice in Liverpool in 1830, devoting himself chiefly to the treatment of diseases of the eye, and in 1834 became one of the surgeons to the Liverpool Ophthalmic Infirmary. In 1839 he founded the Ear Institution, which subsequently was amalgamated with the Ophthalmic Infirmary, the joint institution bearing from that time the name of the Liverpool Eye and Ear Infirmary. He was also surgeon to the Liverpool Deaf and Dumb Institution. He became a Fellow of the Royal Astronomical Society in 1851. In 1858, from failing health, he was compelled to relinquish the more active duty of senior surgeon to the before-mentioned Infirmary for the less laborious office of consulting surgeon, which appointment he held until his death. He was the author of many medical works, most of which were on subjects connected with eye and ear surgery.

He died, somewhat suddenly, December 21, 1864, aged fifty-eight.

William Henry Palmer, Esq., was born on the 7th of November, 1800, and was the son of a London solicitor of high standing. He adopted his father's profession, and was for many years a member, in conjunction with his surviving brother C. J. Palmer, Esq., of an eminent legal firm practising in Bedford Row. From an early age he manifested a strong partiality for exact knowledge, as distinguished from those branches of learning which depend more immediately on the exercise of the imaginative faculties. He was possessed of no mean share of mathematical acquirement, and from this resource derived much pleasurable recreation during his long confinement to the house by a wasting disease. He had, also, a remarkable aptitude for mechanical pursuits, and was a skilled and enthusiastic musician, his favourite instrument being the organ, in the playing of which he was a great proficient. In the year 1848 he was elected a Fellow of the

Society. He had made preparations on his estate at Tunbridge Wells for the erection of a complete Observatory, and to this end had already acquired an Equatoreal of $6\frac{1}{3}$ inches aperture, and $8\frac{1}{2}$ feet focal length, by Mertz, mounted by Troughton and Simms,* besides a transit and other instruments, when the inroads of his malady — rheumatic gout — put a sudden and effectual stop to his astronomical pursuits. The activity of his mind, however, and his love of philosophical studies, suffered no abatement, and he contrived, though to a painful extent disabled by disease, to make himself practically acquainted with the various processes of photography.

After many years of suffering, he expired on the 9th of October, 1864, leaving behind him a memory which will not soon be forgotten, as that of a truly amiable and accomplished gentleman.

William Chadwick Mylne was the son of Robert Mylne, the architect of Blackfriars Bridge. He was born on the 5th of April, 1781, and succeeded his father as engineer to the New River Water Works in 1811, in which capacity he recommended and carried into execution the various improvements adopted from time to time by the New River Company. He also superintended the alterations required by the Act of Parliament of 1852 respecting the filtering the water and preserving it from contamination by the atmosphere and London dirt. He was for more than fifty years the treasurer of the Smeatonian Society of Civil Engineers, and became a member of the Institution of Civil Engineers in 1842. He was elected a Fellow of the Royal Astronomical Society in 1821, and died December 25, 1864, in the 83rd year of his age.

Major-General Joseph Ellison Portlock entered the corps of Royal Engineers as Second Lieutenant, July 20, 1813, and was at once sent to Canada, where he was actively engaged in various military operations. On his return to England in 1824, he was attached to the Ordnance Trigonometrical Survey, and was Chief Assistant of the Director Colonel (afterwards General) Colby. In the execution of that Survey, particularly in Ireland, his exertions were of the greatest value. He was made Captain June 22, 1830; Major, Nov. 9, 1846; Lieut.-Colonel, Dec. 13, 1847; Colonel, Nov. 21, 1854; and became Major-General, Nov. 25, 1857. He was a man of high literary and scientific acquirements, and contributed several

* This instrument has been presented to the President by Mr. Palmer's widow: it will be erected at Cranford in the spring of 1865, and, in all probability, on a more massive stand, the present one being constructed to take to pieces, so as to be portable.

articles on military subjects to the last edition of the *Encyclopædia Britannica*. In 1856 and 1857 he filled the office of President of the Geological Society, and until his health began to give way, was actively employed as a Member of the Council of Military Education, having previously acted as Inspector of Studies at the Royal Military Academy at Woolwich.

He was a Fellow of the Royal and other Societies, and was elected a Fellow of this Society in 1826.

He died Feb. 14, 1864, at his residence, Lota, Blackrock, Co. Dublin, aged sixty-eight.

The Rev. Charles Strong was, it is believed, a native of Somersetshire. He finshed his education at Wadham College, Oxford, of which he was elected Fellow. He became eminent as a Tutor, and amongst his pupils was the late Lord Elgin. Mr. Strong had a valuable living presented to him at Broughton Gifford, Wiltshire; but this he gave up to one of his pupils, he himself having a sufficiency. He devoted himself to scientific pursuits, and of late years his friends were decidedly amongst those who belonged either to the Astronomical or Microscopical Societies. He was much attached to Mr. Dawes, as also to the late Mr. Dollond, and was a true lover of a good telescope and a good microscope. He wrote to the author of this account two or three letters during the week previous to his death: in fact, the last letter received from him was only twenty-four hours before he died; in which, with great zest, he related how he had brought out with his $\frac{1}{12}$ object-glass the delicate markings of *Pleurosigma Marcum*, *Navicula Rhomboides*, and *Grammatophera Subtilissima*, and this, with only a candle as the source of light. His touch was most delicate, and his sight wonderful at eighty-one years of age. When a Tutor he was fond of travelling, and Italy was his favourite country. He was the author of *Specimens of Sonnets from the most Celebrated Italian Poets, with Translations*, and also of another book of *Sonnets* that went through two editions. He was a finished scholar, a perfect gentleman, a true lover of science, abhorring hypocrisy, holding out the right hand of fellowship to all whom his keen observation selected, and when once a friend he remained so. He died Jan. 27, 1864, in the eighty-second year of his age.

Friedrich Georg Wilhelm Struve was born at Altona, in the Duchy of Holstein, April 15, 1793; his father, Jacob Struve, for forty years, filled, with great distinction, the directorship of the High School in that city, and was widely known for his classical and mathematical acquirements. His mother was the daughter of Pastor Stinde, who went to Russia as chaplain to Peter III.; it was this circumstance which subsequently led to the settlement of many of the Struve family in

Russia, but until then the Struves had from time immemorial lived as respectable yeomen in the Duchy of Holstein. Thus our old and honoured associate was descended from the original stock of the Anglo-Saxon race; a descent which many of us remember distinctly expressed itself both in the personal appearance and in the moral qualities of the man. Struve was happily trained by his father into no precocity in his early childhood, but in due time, when removed to the High School, he made such advancement in his studies as at the age of fifteen to be qualified for entrance at the University. In those days of trouble the young student had but little prospect of continuing his studies undisturbed. A constant sense of the oppression of the foreigner and the dread of the French conscription decided his parents, in 1808, to send young Wilhelm to Russia, at that time probably the quietest country in the world, and where his elder brother Carl occupied the post of Classical Lecturer in the University of Dorpat. This university, so soon to be illuminated by the example and the fame of Wilhelm Struve, had been recently founded by Alexander I., immediately after his accession to the throne, and was intended by him to be not only the intellectual centre of the German Provinces of Russia, but to serve as a civilising link between Europe and Russia proper. Here Wilhelm Struve, in accordance with his father's wishes, applied himself exclusively to classical subjects, and it was in this branch of learning that the young student earned his first literary laurels, by an academical exercise "De systemate metrico apud Alexandrinos;" this essay was honoured by a prize, and by being printed at the University expense. It was by this wise and fortunate arrangement of his studies that Wilhelm Struve acquired the power of fluently and accurately expressing himself in the Latin language, thereby enabling him, at a subsequent period, to communicate the results of his researches to men of science living in other parts of Europe, where Struve's native tongue, the German, was at that time but little understood. These early literary pursuits also contributed, in no slight degree, to secure that balance and breadth of mind for which our lamented associate was afterwards so remarkable.

In 1811 Struve took his first university degree in Philology, and it was only after having thus fulfilled his father's desire that he passed to that branch of science which henceforth became the principal object of his life. No doubt, while he was a student at Dorpat, the able scientific lectures of the elder Parrot excited a warm interest in his mind, but it was rather an inner call than any external circumstance which led Struve at length to devote himself to astronomy. Parrot's influence was not confined to the mental stimulus thus afforded to his young philosophic pupil, but by the representations which he made to the University authorities relative to young Struve's

promise of future eminence and his present straitened pecuniary resources, he obtained for him the means of still longer prosecuting his studies at Dorpat. It was partly in this way that Struve from the early age of fifteen ceased to be a burden upon the scanty fortune of his father; but the boy's own exertions and self-denial contributed greatly to the same end. It was brought about in this way. Shortly after Wilhelm Struve had entered the University, he applied for and obtained the post of private tutor in the family of M. de Berg, a wealthy nobleman of Livland, and his first pupil there was the Count de Berg, the present Viceroy of Poland. By this arrangement the young student was necessarily debarred from a regular attendance on the lectures of the place; but this untoward necessity served, as was natural with one of Struve's mind, only still further to quicken his zeal to make the best of such advantages as still remained to him, and to animate his self-reliance.

In 1811, while thus engaged, partly in attendance on the family of the De Bergs, and partly in the prosecution of his own studies at Dorpat, Struve passed on to the class of Astronomy. The Professor at that day was Huth, a man for whose worth and eminent attainments our old Associate ever retained an affectionate and respectful memory. Huth's health was too infirm to permit him to assist his pupil to any great extent, and hence young Struve was, by a happy fatality, or in truer words, by the discipline of Providence, once more thrown upon self-reliance and the resources of his own efforts. The Professor himself was scarcely ever able to visit the Observatory, but he permitted his pupil to make what use of it he could. This Observatory was at that time but scantily supplied with instruments, and even those for the most part were not in a condition for actual use. Among these instruments was a Transit by our countryman Dollond, and the excellence of the object-glass attracted the special notice of the embryo astronomer. The pillars for this instrument were, it is true, erected, but upon them there was no provision existing for the attachment of the Y's and the other subsidiary apparatus, while the body of the instrument itself had never been removed from the case in which it had been packed. For the mounting of this instrument young Struve could obtain no adequate assistance in the city of Dorpat, but was thrown entirely on the workmanship of his own hands, and the guidance of his own inexperienced judgment. Nevertheless, the work was done, and well done; and in after days Struve would often recur to the fortunate difficulties under which his earliest efforts were made. We must not forget that Struve at this time was only in his nineteenth year.

Early in the autumn of 1813 Struve took his degree of Doctor of Philosophy, and on that occasion wrote his first memoir on an astronomical subject, namely, *De geographica*

Speculæ Dorpatensis Positione. In this paper, among other matters, he gave the first determination of the longitude of that Observatory, deduced from occultations observed by himself during the preceding year. In November 1813, a few weeks after this thesis, he was appointed extraordinary Professor of Mathematics and Astronomy, and two years later, upon the death of Huth, he was advanced to the ordinary professorship. In this capacity his duty was not only to attend to the Observatory, but to lecture also on Astronomy and the higher branches of Mathematics; each subject no doubt suffering from this combination of duties, notwithstanding the efforts of the professor to prevent it. In 1822, however, the two offices were happily separated, and Struve was henceforth enabled to devote his zeal and his abilities exclusively to the proper work of an Observatory.

Having thus arrived at that point in our venerated Associate's career when he was appointed the chief of an Observatory, soon to be rendered by his labours famous to all time, we may for a few moments not improperly revert to the circumstances which years before, indicated the bent of his mind, and, in a certain degree, shaped the after-course of his life. In August, 1811, young Wilhelm Struve, while yet a student, and with extremely slender means at his disposal, verified the orbital motion of the two components of *Castor*, predicted by the elder Herschel in his immortal memoir of 1803, and which by this time was completed to the extent of thirty degrees. This first success had a decided influence in directing Struve's mind to the abundant harvest which he foresaw might be reaped from a zealous devotion to Sidereal Astronomy. Nearly at the same time, while spending the summer at Sagnitz, in the house of his friend, M. de Berg, Struve's attention was drawn to Geodesy; and the early success which here again attended his first attempts, laid the foundation for that other gigantic work upon which, together with his labours in sidereal astronomy, rest the fame and the scientific services of this great observer. Although provided with the feeblest conceivable instrumental means he made excursions in the neighbourhood of his friend's house, in order to see if it were possible to make a triangulation of that part of Livland. While practising himself in the use of the sextant, for that purpose, a singular accident befell him, and for some time put a stop to his geodetical studies. The French army at this time was invading the Russian frontier, and against it a Russian corps had been despatched to Livland in order to prevent the French army from penetrating through the Baltic provinces to St. Petersburg. Some officers of this corps seeing young Struve engaged with an instrument and a note-book, mistook him for a French spy, and, notwithstanding his protestations, marched him off, for full a hundred miles, as a prisoner to head-quarters, and there, not without some difficulty, he was liberated by the commander-in-chief, on the

express understanding that as long as the war continued he would not again, by similar pursuits, expose himself to suspicion. Three years after this occurrence, Struve, at the invitation of the Economical Society of Livland, undertook to make a triangulation and map of the entire province; and this work he accomplished with great ability, although he had no instrumental means at his disposal beyond an excellent 10-inch sextant, by Troughton. This work, thus commenced with a comparatively insufficient instrument, forms the starting-point and the nucleus of that noble survey of the Russian empire, which for nearly half a century occupied the thoughts and the abilities of our lamented Associate.

From 1813 to 1839 Struve continued at his post at the Observatory of Dorpat. As we have already seen, the means at his disposal were wholly inadequate to the most modest requirements of an astronomer. It was not long, however, before the success of his labours attracted the attention of the Russian government, and through the benevolent intercession of Prince Lieven, then Chancellor of the University, and as an acknowledgment of the services of the professor, the Observatory was furnished with such instruments and pecuniary means as soon raised it to the rank of a first-rate establishment. Thus, in 1821, the Meridian Circle was obtained from Reichenbach and Ertel, and in 1824, Frauenhofer's famous 9-inch Refractor was added, at once the masterpiece of that great artist, and the commencement of a new era in the history and employment of the telescope.

Struve at first worked alone in the Observatory thus munificently furnished; occasionally, indeed, he was assisted by a few volunteers from among his pupils, and notably so by *Knorre*, who subsequently, and for forty years, was the well-known director of the observatory at Nicolaiff; but it was not until the year 1826 that he obtained, in the person of M. Preuss, a permanent observer, who by applying himself with much ability to the meridian circle, enabled Struve to devote his attention to the observation of double stars with the great refractor.

In taking even a cursory survey of Struve's labours at Dorpat with this noble instrument, it becomes necessary to revert, in some degree, to the state of sidereal astronomy before he commenced his work. In 1803, Sir William Herschel had announced the binary nature of several of the double stars; nevertheless, partly from the extreme novelty of the views set forth by that great philosopher, partly from the deficiency of the optical means then existing, and partly from the great difficulty of manipulating the micrometrical measurements, the subject remained in abeyance and almost untouched during the succeeding fifteen or sixteen years. In 1816, Sir John Herschel did, however, commence at Slough a review of his Father's double stars, but owing to some of the difficulties

already alluded to, he made but inconsiderable progress. Some of these measurements so taken are recorded in the joint communications made by Sir John Herschel and his colleague, Sir James South, to the Royal Society in 1824: among others will be found a remarkable measurement of *Castor*, when the two component stars happened to be on the same parallel. We have already adverted to the then young Struve's measurement of the same remarkable star, and to the effect which it had on the direction of his energies: this, however, was but a single and isolated result, and it was not until some years later, namely, in 1819, that the record of measured angles of position and distance began to be at all consecutive at Dorpat, though differences of right ascension and declination had been pretty copiously observed. In 1820 appeared Struve's first Catalogue of 727 double stars, arranged in the order of their right ascension, together with their corresponding declinations. This Catalogue was expressly intended to facilitate the observation of these objects, either with meridian or with equatoreally-mounted instruments, and effectually revived the subject as one of general astronomical interest.

Nevertheless, praiseworthy and valuable as were these new attempts, it was not until the erection of the great Fraunhofer Refractor in 1824, at Dorpat, that M. Struve became possessed of an instrument worthy of the subject, and competent, not only to afford facility and precision in respect of measurement, but to add largely to the list of known double stars.

The result of the first two years of his observations with this famous telescope was that most remarkable work *Catalogus novus generalis stellarum duplicium et multiplicium*, which appeared in 1827, and will for ever be considered as forming a memorable epoch in Sidereal Astronomy. Nor is this great work remarkable alone for its copious and valuable lists of 3112 double or multiple stars duly arranged in their order of right ascension, and 2343 of which had not been previously described by any astronomer, but still more so for a great physical fact which it announced for the first time. In this catalogue it is shown that the closer classes of double stars, namely, those whose mutual distance is less than 4″ exceed out of all proportion, not only what might be expected from a calculation of chances on the hypothesis of casual or optical juxtaposition, but even in point of numerical majority, those of either of the other classes. The existence of such a fact affords, in the opinion of those competent to form it, a convincing proof of a real physical connexion, and (independently of any question as to orbital motion) places these juxtaposed objects before us, neither as casualties of situation as seen from the earth, nor as mere exceptions to a more general rule of isolation, nor as mere *curiosities* of the sidereal heavens, but as entering largely into the general plan and constitution of the universe. Later observations, carried on both by M.

Struve himself and by others, with even larger instruments than the great Dorpat refractor, have confirmed this most notable result, and have shown that it is but an ordinary circumstance to find stars previously regarded as single, to be in reality composed of two *very close* individuals. It will enhance our respect for the memory of our lamented Associate, and enable us to form some idea of the labour and devotion required for the formation of this catalogue, to remark that in the preface to the Petersburg Catalogue it is stated to have been the result of the examination of 120,000 stars, and that it was one individual who executed this examination with his own eyes and hands.

The formation of this Catalogue was, after all, the commencement only of a work of far greater labour in this department of astronomy. Struve's next undertaking was the determination of the angles of position, distances, magnitudes, and colours of all the objects therein enumerated, together with their exact right ascension and declinations, each resulting from several nights' observation. The results of this immense undertaking he published in the year 1837 in a magnificent work entitled, *Stellarum compositarum mensuræ micrometricæ*, followed, in 1852, by another work, bearing the title, *stellarum fixarum, imprimis duplicium et multiplicium, Positiones mediæ*, with their proper motions computed when practical from earlier observations.

Another branch of what, with some propriety, may be called the *Physique du Ciel sidéral*, to which Struve directed much of his attention, was the determination of the *law of density* in the distribution of the stars with respect to the plane of the Milky Way. His researches on this subject were not indeed published until after he had removed from Dorpat, as we shall speedily see, but it is here, perhaps, that we can with greatest convenience refer to the fact. The great work which contains the result of his labours, is entitled *Etudes d'Astronomie Stellaire*, published in the year 1847. By a series of calculations, founded on the number and distribution of stars of sufficient lustre to admit of being individually catalogued, as well as by the star-guages of Sir W. Herschel subjected to a careful and systematic analysis, he has in this work clearly shown that in the northern hemisphere at least, (northern, that is, when referred to the bisection of the heavens by the Milky Way) the distribution of the stars exhibits a distinct and unequivocal relation to their angular distance from the plane of that sidereal ecliptic. Nor is this view wanting in confirmation. In the same year that Struve published his researches on this great problem, Sir John Herschel gave also the results of his own investigations of the *southern* hemisphere, and the numerical expression obtained by him for the gradation of stellar density, is singularly coincident with that resulting from Struve's investigations of the northern

heavens. As the two results were obtained from observations made with telescopes strictly comparable, and were each arrived at independently and without the knowledge of the other, it seems that this great physical generalisation may be regarded as perfectly established.

Such are some of the great results which form the high rewards of Struve's loyalty to his duties at Dorpat. The year 1833 brought a great change in his life. In the autumn of that year the Emperor Nicholas resolved to erect a great central observatory for the empire of Russia; it is honourable to the Czar's memory to record that the suggestion was wholly spontaneous, and we feel no surprise that our Associate was a most influential member of the commission entrusted with the execution of the Emperor's noble design. The prosecution of this work occupied much of Struve's attention, and necessarily compelled frequent and prolonged visits to the capital, until the spring of 1839, when the building having been completed, Struve took up his permanent residence at Pulkowa as director in chief of the Central Observatory of Russia.

The creation of an Observatory to be, from its commencement, established for well-defined and specific purposes, distinctly set forth in a formal document; and without restriction in cost, to be furnished with instruments constructed by the ablest artists who were at the same time encouraged to new efforts, the observatory and its ample staff being, at the same time, munificently endowed with pecuniary means and all other requisite appliances, is a circumstance unique in the history of science. Nor could this magnificent plan have been successfully executed, had not the man been at hand qualified by nature and experience to organise and direct so difficult an undertaking. It is unnecessary here to describe at any length the Observatory of Pulkowa, but it would be wrong not to refer to the judicious plan of observation which Struve proposed to follow, so as best to realise the generous intentions of its imperial founder. Fully aware of the incomparable value of the Greenwich lunar and planetary observations, and of its traditions in other respects, Struve determined, from the first, to adopt a course wholly different from that followed at our National Observatory. Hence, observations of the moon and planets were to be made on exceptional occasions only, the main strength and efforts of the observatory being directed to the astronomy and physics of the sidereal heavens. It was proposed also not to publish an annual volume of observations, but, after having organised systems of specific research, often of necessity extending through several years, to give the results to the world only when each project was completed, and then with the name of the particular observer attached. How well this plan has been executed the records and scientific memoirs which have proceeded from Pulkowa sufficiently attest. And, lastly, it

will not be without its interest to record that, in 1844, when Struve published his elaborate description of Pulkowa, there were no less than 103 persons, including the children, domiciled within the precincts of the Observatory. This numerous family comprised seven astronomers, several *savans* connected with the geodesy of the empire, a secretary, an engineer-in-chief, a cabinet-maker, with ten artisans for the repair of the instruments and the furniture, and eight discharged non-commissioned officers for the service of the place. Assuredly it was no ordinary man who could secure, as Struve secured, order and good-will in so considerable and multifarious an establishment. For the endowment of this noble institution the Emperor of Russia, with truly imperial generosity, assigned no less a sum than ten thousand pounds per annum. The servant was worthy of the master.

Meanwhile, and for nearly half a century, extending almost throughout our venerated Associate's directorships both at Dorpat and at Pulkowa, run continuously the gigantic operations connected with the measurement of the Russian and Scandinavian Arc of Meridian, and the Trigonometrical Survey of the enormous Russian empire. The genius of Struve presided over this vast undertaking, ever devising, co-operating, and not seldom working with his own hands and eyes, and on more than one occasion amidst ice and snow. This arc of meridian, extending through 25° 20′, from Ismail at the mouths of the Danube to Fuglenaes on the Arctic Ocean, exceeds in magnitude even our own Indian arc, from Cape Comorin to the Himalayas, the execution of which alone, and with no other work, has been sufficient to raise the fame and exhaust the labours of Lambton and Everest.

Some idea may be formed of the amount and variety of Struve's occupations at this time from the following quotation from his great work on the subject of this very arc. Speaking of that portion which runs through Livland, he says:—"Undoubtedly I could have completed this work long before, had it been the sole object of my scientific duties; but, in 1821, Reichenbach's meridian circle arrived at Dorpat, and at length, in 1824, I was put in possession of Fraunhofer's magnificent equatoreal, ordered since 1820, and I thought that my first duties pointed to the immediate use of these exquisite instruments. Hence, I did not consider myself authorised to absent myself from Dorpat for more than a few weeks' work at a time in geodetical proceedings. And I think that I ought here to explain, that between 1821 and 1827 (which period embraces the field-work of the Baltic arc), I made, reduced, and published without any assistance, the meridian observations recorded in volumes III. IV. V. VI. of the Dorpat Annals; at the same time I also finished the revision of the survey of the heavens, which furnished the *Catalogus novus stellarum duplicium*, published in 1827; and besides this I

had to give an annual course of lectures on Astronomy to the University, and of Geodesy to the Imperial staff."

Such labours, great as they were, are not now referred to as being by any means without their parallel among scientific men, on the contrary, they form the rule rather than the exception; but they are mentioned here because they may well serve to remind us, that such is the cost at which our knowledge is advanced, and for which alone the world accords imperishable fame to her sons.

Struve visited England on four different occasions. The first time was in 1830, when it so happened, that a committee was sitting for the improvement of the *Nautical Almanack;* he was invited to assist in its deliberations, and by his ability and excellent temper contributed towards bringing its labours to a successful conclusion. In 1844 he came to England for the purpose of determining the difference of longitude between the observatories of Pulkowa and Greenwich. A step had already been taken towards the completion of that important but difficult operation, by ascertaining, in 1843, the difference of longitude between Pulkowa and Altona. In those days,—it may seem strange indeed, that we naturally fall into such expressions while speaking of but twenty years ago, but the amazing advances which, during that short interval, have been made in the application of science to art, justify the terms—in those days, the only known method existing for the exact determination of differences of longitude between two geographical positions, was by the repeated transmission of many chronometers from the one place to the other. Hence, it was necessary for Struve to organize, and personally superintend, a series of chronometric expeditions, first between Pulkowa and Altona, and then between Altona and Greenwich. In the former expedition, not less than sixty-eight chronometers were sixteen times carried across the Baltic; and in the latter, forty-two chronometers passed sixteen times over the German Ocean and the Thames. In the present day, owing to the combined labours of Oersted and Wheatstone, all this tedious and cumbersome operation is replaced by the mere automatic action of the clock itself, whereby a series of metallic contacts are made, conveying the precise time, to the small fraction of a second, through the electric wire to an observer waiting in quietness for the expected signals at some distant place. All honour be to Struve, and to others like him, who, toiling along rivers and seas, and without our wonderful appliances, by patient genius obtained results comparable in accuracy with our own.* Nor may we here omit the mention of an

* In 1844 the Astronomer Royal determined the longitude of Valentia, in the west of Ireland, to be $41^m\ 9^s{\cdot}67$ W., by means of ten transits of thirty pocket chronometers to and fro. In 1862 the longitude of the same place was re-determined by galvanic signals given by the clock itself, and the final result was $41^m\ 9^s{\cdot}81$ W.!—*Mem. R. Ast. Soc.* Vol. xxxii.

incident, which exhibits in a characteristic manner the true greatness of Struve's mind. After he had successfully completed the very troublesome operation before alluded to, and when it had become necessary to arrange and publish the result, for geographical and other purposes, the question arose, shall the astronomical precedence attached to the *first meridian of longitude* be assigned to Pulkowa or to Greenwich? There could be no doubt that Struve's heart was in Russia, rather than in England, and we have already seen how in external magnificence Pulkowa utterly eclipsed the unpretending buildings at Greenwich; but Struve, like a true astronomer, remembered the long line of illustrious men who had toiled at Greenwich, the old traditions of Flamsteed, and Halley, and Bradley, and to Greenwich he assigned the astronomical precedence.

Struve was in this country again in 1847. This time, the main object of his visit was to carry back with him to Russia one of the two standard bars used in the great Indian Survey, and without which it was impossible to utilize and connect the measurement of the Indian arc, with that of the still greater Russian and Scandinavian arc just completed. On this occasion, he joined the British Association, which that year fortunately assembled at Oxford, and it was thus that Struve either acquired or consolidated that strong personal regard which united him, in a peculiar degree, with the principal scientific men of England in almost every branch. Perhaps it may be allowable for the writer to record that his first acquaintance with this most amiable man was made at this period when, at the house of Sir John Herschel, and not long after the memorable discovery of *Neptune*, he, for a few days, was permitted to associate with a phalanx of scientific veterans rarely assembled in one spot,—Adams, Airy, Herschel, Leverrier, and Struve, forming the list.

Ten years later, viz. 1857, found Struve in England for the last time. He had never failed in public documents and in private communications to speak in affectionate terms of the ready aid and hospitality which he had received at the hands of the present Astronomer Royal, Mr. Airy. His headquarters were, therefore, again as of old, at Greenwich. But now, though in his sixty-fourth year, the indomitable energy and the genius of work in the man, brought him thither on a project of still greater magnitude than the arc of meridan which he had just completed. In early youth, while honourably supporting himself in Livland as tutor in the family of the De Bergs, he had cast a wistful eye over the level tracts which north and south, east and west, are a characteristic feature of European Russia. Our great countryman, Dr. Arnold, used to say, with but slight exaggeration, that there was scarcely a hill between Rugby and the Ural mountains to shelter him from the east wind. Arnold observed this with

the eye of a geographer; Struve knew it, and utilized it as an astronomer.* No sooner then was the Russian and Scandinavian arc from north to south completed, than Struve set to work to organise and arrange the measurement of an Arc of Parallel from east to west, of still more gigantic dimensions. He proposed to extend it throughout the entire breadth of Europe; from Orsk, at the foot of the Ural Mountains, to Valentia, at the western extremity of Ireland, ranging over perhaps a twelfth part of the equatoreal circumference of the earth. The operations for measuring this arc would necessarily lie in many lands; and, perhaps, this man of no jealousies was, if not the only man, at least the one best fitted to negotiate with the various governments, and men high in office, both in state and science, without whose concurrence and aid tho execution of the vast project was impossible. The Emperor of the French and other state officials received Struve with especial distinction. It was to arrange for the prosecution of that portion of the arc of parallel which lies in England and Ireland, and also of that part which connects England with Belgium, that Struve now came to Greenwich. In this country he was warmly seconded by our own government, by Mr. Airy, Colonel Sir Henry James, Captain Clarke, and other *savans* connected with the geodesy of Great Britain. It is sometimes accorded by a divine providence, wiser than ourselves, that a man at the age of sixty-four may arrange and even commence so vast a plan, but it is not granted that he may complete it. So Struve laboured, but it is for other men to enter into his labours. In the following year, 1858, came the first attack of a cruel malady, which might have warned him that his active labours were drawing to a close. When, however, he could no longer take the field and observe, we are informed on the best authority, that he would sit at his writing-table for fourteen or fifteen hours in the day, endeavouring to further with his pen that great undertaking which he could not assist with his hands.

Before concluding our estimate of the permanent results of Struve's labours on the advancement of astronomy, it is necessary to observe that the data for our more accurate knowledge of the constants of precession, nutation, and aberration, as now generally adopted by astronomers, were furnished by observations made by himself or under his immediate direction, in the interval between 1822 and 1841. Again, in addition to his discovery of the existence of a law in the distribution of stars in space and in the proximities of multiple stars, of which we have already spoken, for Struve may properly be claimed

* Struve remarks that, along the arc between the mouths of the Danube and the Arctic Sea, there is no hill 1200 feet high. Over a great portion of it the country is so level and wooded that it was often necessary to erect lofty scaffolds in order to see the necessary signals.

what Sir John Herschel happily terms "the first impression that was made"* on the general problem of the distances of the fixed stars from the Sun. It was humiliating to the astronomer (nay, he had almost acquiesced in the belief that for wise purposes it was designedly so) to think that an innumerable multitude of bright objects, which he could not do otherwise than regard as worlds, were within his sight, yet beyond the reach of his geometry to measure. Our Associate, however, resolved to determine, if determined it could be, whether this limit had actually been set to the bounds of human knowledge, and in the years 1819–21 he succeeded, by sagacious and diligent observations of 27 circumpolar stars, in showing, beyond a doubt, that certain indications of parallax existed sufficient to encourage further efforts with more adequate instrumental means than he at that time possessed. The history of the definite settlement of the question of stellar parallax is not a little curious, and Struve's part in it is sufficiently conspicuous. Our countryman Henderson, in 1831–2, at the Cape of Good Hope, observed *α Centauri* with the mural circle, and on his return to England shortly afterwards deduced a parallax of about 1″ for that remarkable star. Struve at Dorpat, from micrometrical measurement made with Fraunhofer's instrument in the years 1835–8, obtained a parallax for *α Lyræ*, amounting to 0″·261. Nevertheless, astronomers, after their manner of most rigid and impartial scrutiny, decided that possibly the shadow of a doubt rested upon both these sets of observations, and resolved to wait for the results of fresh measurements. Meanwhile, Bessel a year after, and from observations made with the great Heliometer at Königsberg, deduced a parallax of 0″·348 for 61 *Cygni*, such as to be wholly beyond the reach of cavil. Subsequently Peters confirmed Henderson's result of the existence of a parallax in *α Centauri*, and M. O. Struve vindicated the general truth of his father's deductions. Such, then, is the share which must be assigned to our Associate in the determination of this most interesting, but difficult cosmical question.

Nor must we pass over our late Associate's *Description de l'Observatoire Central de Poulkova*, given to the world in 1847. It would be but an obvious and inadequate remark simply to say that this is the most sumptuous and complete work ever published on the description of an observatory, its instruments and its arrangements; and a monument to the enlightened generosity of the Russian government, who defrayed the cost of its publication. A perusal of it can scarcely fail to kindle the admiration of every one who is endued with

* Address of Sir John Herschel to the Royal Astronomical Society, 1841.

a taste for practical astronomy. What is of far more importance, almost every page indicates the perfect mastery of the author over the instruments which he thus admirably describes, and attests the scrupulous care with which he attended to the minutest circumstances which could in any way contribute to the accuracy of their construction, or of the mode of handling them. Happily this most important work has on several occasions served as a guide for building and organizing other observatories on the continent of Europe. But while we are bound, in the interests of scientific truth, to speak thus respectfully of this truly admirable work, and of the Observatory which it describes, it is impossible for us not to turn our thoughts for a moment to our own National Observatory and to its present able Director; not indeed in the spirit of contrast or comparison, but solely in the spirit of duty. Since the establishment of Pulkowa, Greenwich also has been furnished with instruments, entirely new, wholly devised by the Astronomer Royal, and constructed entirely under his superintendence. These instruments differ greatly from those erected at Pulkowa, as might be expected from the difference of genius with which the two nations are inspired; but if the descriptions of these admirable instruments were collected from the several monographs in which they are dispersed, they would form a volume every way worthy of being a companion volume to Struve's grand description of the great Russian Observatory.

Nor are the names of our great artists, Dollond, Ramsden, Troughton, Simms, and Cooke, in any respect unworthy to be placed side by side with Fraunhofer, Ertel, Reichenbach, Repsold, Mertz, Cauchoix Secretan, and others. In the great Alhambra of Science there are niches for them all. In gladly awarding our meed of thankful acknowledgment to the memory of Struve, and to the astronomical mechanicians who so ably assisted him, we have felt it our duty to say a word of what is due to the genius of their fellow-labourers in England. In so doing we are here claiming no pre-eminence nor asserting any priority; invidious comparisons, if at all and anywhere out of place, would be pre-eminently so in a memorial notice of a man like Struve, for it was one of the characteristic features of that great man's life that, although often provoked, he was never known to contest a scientific priority; such contests, he said, were not only destructive of the peace of a philosopher's mind but highly prejudicial to the interests of science.

Struve was, as might be suggested by his labours, a man of uncommon physical strength, greatly corroborated, as he believed, by gymnastic exercises in youth: until the first attacks of his painful malady in 1858, of which we have already spoken, and which ultimately brought him to the grave, he used to say that he had never known what illness

was.* By the advice of his physicians he was at length induced to cease, at least temporarily, from his incessant work, and travel through Europe for the restoration of his health: that result was not to be; as in other cases, so in his, it was too late. In Struve's illness there occurred a phenomenon which, though at the time supposed to be extremely singular, is not altogether uncommon. When he began to recover from the exhaustion occasioned by the first attack of his malady, his memory, for all events of recent occurrence, wholly failed him; while, at the same time, it exhibited its usual, or even increased tenacity in things long since passed away. On such occasions he would seem to be living wholly in the scenes of the past, reciting passages in Greek, Latin, or Hebrew, and speaking in some of those many dialects in which he had learned to converse in his youth. In the midst, however, of this vivid resuscitation of the past, co-existing with the temporary oblivion of all recent associations, it is a touchingly suggestive circumstance to record that he never forgot the face of a friend.

At length, reluctant to continue as the nominal head of a great establishment, which he no longer felt himself able personally to direct, in December 1861 he requested permission to resign his post. This permission was granted, accompanied, among other special marks of honour, with the grant of an hereditary estate by his sovereign; and thus the Observatory of Pulkowa passed to the directorship of his worthy son, M. Otto Struve. That the mantle of the father may descend upon the son is the undoubting hope and expectation of all who are interested in the science of astronomy.

On the 19th of August, 1864, a quarter of a century having now elapsed since the inauguration of the Observatory, a great gathering of astronomers from all parts of Europe assembled at Pulkowa, to pay their respects, and, as it proved, their last respects, to the man whose character and talents had shed a lustre even on the noble science of their common pursuit. Among those present on this happy occasion was the President of our own Society; of the others many had been Struve's astronomical pupils in former days, but now they occupied high and responsible positions of their own; from the former we learn how the venerable old man, now in his 72nd year, shook off for a time the bodily feebleness to which his unceasing malady had reduced him, and assuming the animation of younger years, thanked those around him for the affection which had brought them together, and acknowledged the kindness and co-operation which, through a long life, he had met with in the prosecution of his labours. But what at Pulkowa,

* This is not quite strictly correct. Struve used to say, with an easy pleasantry, that Fraunhofer's noble instrument was rightly named *the Great Refractor*, for he and his friend Schumacher had each broken a leg while using it.

on this and on other occasions, struck our President the most, even among the many other remarkable features of that Imperial establishment, was the oneness of purpose, mutual confidence, and friendliness of intercourse, which there seemed to have found an especial home. We could fondly believe that it was thus ordained for the old astronomer to die, like a patriarch, in the midst of his children, for within a few weeks of that memorable jubilee, on the 23rd of November, 1864, Struve was called to his rest.

Struve was twice married: his first wife was a German lady, Emilia Wall, by whom he had twelve children, of these eight survive; his second wife, now his widow, was the daughter of his old colleague, Bartels, at Dorpat; by her he had issue six children, and of these four are still living. It may be interesting here to state that, notwithstanding the multiplicity and engrossing character of Struve's occupations, he always found time personally, and with affectionate concern, to superintend the education of his children.

Such are the records of this great man's life, so far, at least, as they are suited to a memoir like the present. Whatever is mortal of Wilhelm Struve rests in the churchyard attached to the beloved institution which he so long adorned. His grave lies under the shadow of its domes, and was selected by himself: but it is not these domes alone which constitute his monument; the spirit of the man still breathes in the zeal, the labours, the unanimity, which survive the master, and reign within them. That spirit will be reproduced again and again in future ages when other men, animated by the story of his example, shall endeavour to follow in his steps.

[C. P.]*

The following are the principal works of W. Struve:—

Observationes astronomicæ institutæ in Specula Dorpatensi Vol. I.–VIII. 1817–1839.

Beschreibung des grossen Refractors von Fraunhofer. 1825.

Beschreibung der Breitengradmessung in den Ostsee-Provinzen Russlands. 3 vol. 1831.

Catalogus novus stellarum duplicium et multiplicium. 1827.

Stellarum duplicium et multiplicium mensuræ micrometricæ. 1837.

Beobachtungen der Halleyschen Cometen. 1839.

Description de l'Observatoire central de Poulkova. 1845.

Librorum in Bibliotheca Speculæ Pulcovensis contentorum Catalogus systematicus. 1845.

Positiones mediæ stellarum fixarum in zonis Regiomontanis

* In the compilation of this éloge, the writer desires to record his grateful thanks for the assistance given by the Astronomer Royal, Sir J. Herschel, Mr. Warren De La Rue, and M. Otto Struve.

inter—15° et +15° decl. observatarum ad 1825 reductæ, auctore M. Weiss. Edi curavit et præfatus est W. Struve. 1846.

Beschreibung der zur Ermittelung des Hohenunterschiedes zwischen dem Schwarzen und Caspischen Meere ausgeführten Messungen. Herausgegeben von W. Struve. 1849.

Etudes d'astronomie stellaire. 1847.

Expédition chronométrique entre Poulkova et Altona. 1844.

Stellarum fixarum, imprimis duplicium et multiplicium, positiones mediæ pro epocha 1830,0 deductæ ex obs. meridianis annis 1822 ad 1843 in Specula Dorpatensi institutis. 1852.

Recueil de Mémoires presentés à l'Académie des Sciences, pas les astronomes de Poulkova. 1853.

Arc du méridien de 25° 20′ entre le Danube et la mer Glaciale. 2 vol. 1860.

For numerous other papers and memoirs of W. Struve see the Catalogue of the Library of Pulkova, published in 1860.

Proceedings of various Observatories.

Royal Observatory, Greenwich.

No important changes, instrumental or otherwise, have been introduced into the Royal Observatory, Greenwich, during the past year. The astronomical work for 1863 has been passed through the press, and the reductions of the observations made during the year 1864 are in a forward state.

The convention between the Observatories of Greenwich and Paris, by which the Greenwich Observatory is charged with the meridional observations of the asteroids from new moon to full moon, and the Paris Observatory from full moon to new moon, has been found to afford relief without any loss of valuable observations. Opportunity has been taken of this to extend the star-observing: all the stars contained in Bessel's *Fundamenta*, which have not been re-observed at Greenwich during the directorship of the present Astronomer Royal, have been carried into the working Catalogue, and a considerable number of observations already obtained. A number of stars near the zenith, accurate places of which were required by the Ordnance Survey Department, have also been observed during the past year; besides this, many stars have been observed at the request of individual astronomers who required observations in connexion with astronomical investigations on which they were engaged. It is almost superfluous to state that these works have been carried on without in the slightest degree infringing upon what has always been considered the standard work of the Observatory: the meridional observation of the Sun, Moon, and principal planets at all possible opportunities, the extra-meridional observation of the

Moon, and the fixing with accuracy the places of the *Nautical Almanac* stars, and stars useful for the purposes of nautical astronomy.

During the autumn of last year Col. Forsch, Capt. Zylinski, and Doctor Tiele, gentlemen connected with the measurement of the great arc of parallel between Orsk on the Oural, and Valencia on the west coast of Ireland, were engaged in England in determining the differences of longitude between Greenwich and Bonn, Nieuport and Haverfordwest. These gentlemen also determined with their own instruments, for uniformity of plan and for the sake of comparison, the latitude of the Greenwich Observatory.

Radcliffe Observatory, Oxford.

In this Observatory the same classes of objects have been the subjects of observation as in preceding years, and no alteration has taken place either in the instruments or the personal staff of the establishment.

The Carrington Transit-Circle has been used without intermission for the continuation of the observations of the stars of this hemisphere from the fifth to the seventh magnitudes, and for observations of the Sun, the Moon, and some of the planets. The stability and general excellence of the instrument are still further confirmed by the continued use of it; and it is attempted to give the utmost precision to the results by the same application of its collimating telescopes as at Greenwich, and by reflexion-observations of stars north and south of the zenith and of the nadir point on every evening when such observations are practicable. The number of stars of all classes observed in the year 1864 is 1216.

The Heliometer has been chiefly used, as in the preceding year, for the completion of the re-observation of Struve's *Lucidæ*, and the remark made by Mr. Main in the last Annual Report is still applicable, namely, that comparatively very few of them exhibit any conspicuous orbital motion. The polar and equatoreal diameters of *Mars* were observed at the recent opposition of the planet, but, owing to unfavourable weather and to the total failure of the galvanic illumination of the scale at the most critical period, only six satisfactory sets of observations could be made. The diameter at the maximum amounted to only 17″; and it is doubtful whether, under any circumstances, so small a quantity as the reputed ellipticity amounts to, could be measured on a disk of this magnitude. At the preceding opposition in 1862 the diameter was larger by one-third.

Several occultations of stars by the Moon have been observed and thoroughly reduced.

The meteorological observations have been made and dis-

cussed with the same rigour as in preceding years, and the photographic sheets are found very useful in the comparison of storms passing over Oxford and other places where there are found similar self-recording instruments.

The reduction of the astronomical observations is in a more advanced state than it was at the corresponding period of last year. Those for 1863 are very nearly completed (the transits being absolutely finished and written out into ledger, and the zenith distances wanting only the completion of the computations of the corrections to Mean N.P.D.). The transits for 1864 are in a very forward state, the clock-book being completed and the reductions to Mean R.A. nearly so.

The printing of the Astronomical Results for 1862 is completed, and that of the Meteorological Results is in progress. With greater vigour on the part of the printers this volume might have been finished and published some time ago. It will contain about 300 pages, notwithstanding the omission of the details of the observations and the other attempts made to compress it into as small a form as possible.

With regard to the compilation of the Star-Catalogue, which will include all the results of the observations of stars made from the years 1854 to 1861 inclusive, all the places have been reduced to the proposed epoch of the Catalogue, namely, the year 1860. And Mr. Main hopes to be able shortly to devote a good deal of time to it, as in the ensuing year his personal labour will not be required to so great an extent in the reductions of the ordinary observations.

It will be seen by this statement that the same industry and the same economical application of a small observing force are exhibited as in the preceding year, and it is hoped that the results when published will fully sustain the reputation of the Radcliffe Observatory.

Cambridge Observatory.

It was mentioned in last year's Report, that Professor Adams had been fortunate enough to secure the services of Mr. A. Graham as first assistant. Mr. Graham entered on his duties in April last, and Professor Adams has every reason to be satisfied with the zeal and intelligence which he displays in the discharge of his duties.

The Meridian Observations during the past year comprise observations of the Sun near the Equinoxes and Solstices ; observations of the planets *Jupiter*, *Uranus*, *Neptune*, and *Metis ;* and also a considerable number of observations of stars, which have been selected from Oeltzen's Comparison of Lalande's *Histoire Céleste* with Argelander's Northern Zones, for the purpose of re-examining the places of all those stars which appear from that comparison to have a sensible amount of Proper Motion.

A very complete series of observations has been made for the purpose of determining, by means of the method introduced by Professor Challis, the errors arising from the form of the pivots of the Transit instrument.

With the Northumberland Equatoreal, observations have been made of Comet I. 1864, and also of the places of 747 Ecliptic stars, with the object of completing the Markree Zone observations, in parts of the zodiac having large Southern declination. These observations have been made by means of a new eye-piece of Steinheil's construction, made by Mr. Cooke of York, and provided with a square bar micrometer, on a plan devised by Mr. Graham, and employed by him with great advantage at Markree. An eye-piece provided with a diagonal reflector for observing the Sun, has been made by Mr. Simms, and its performance has been found satisfactory. The observations are nearly all reduced to the end of 1863. Vol. XX. containing the Meridian Observations for the years 1855 to 1860, inclusive, made by Professor Challis, has been lately published. In the introduction, which is of considerable length, a full account is given of all particulars relating to the reduction of the observations.

Liverpool Observatory.

The extensive works now in progress in the immediate neighbourhood of the Observatory, have somewhat interfered with the general routine duties of the establishment during the past twelve months. In the February *Notice* of the Society for last year, it was stated that the site on which this Observatory stands would shortly be required for dock accommodation, and that it would be necessary either to remove the building some two or three hundred feet south of its present position, or find a more eligible site. At the earnest request of Mr. Hartnup, that the Observatory be removed as short a distance as possible from its present position, the engineer first decided on allowing it to remain on the new Waterloo Dock Pier Head; but when the plan was brought before the Works Committee it was found that such an arrangement would impede the working of the docks now in course of construction, and Mr. Hartnup was requested by the Chairman of the Mersey Docks and Harbour Board to find another site; the engineer at the same time giving it as his opinion that any place that could be selected on the dock-quays, or near the margin of the river, might in a few years be required for dock extension, and in that case the Observatory would have to be removed again.

Many gentlemen in Liverpool who have taken great interest in the Observatory were desirous of keeping it on the east side of the Mersey, but unfortunately the Dock Board

had no lands eligible for this purpose. On the west side of the river, however, they possess two acres of land on Bidston Hill, on which there are at present a lighthouse and a telegraph-station ; and it has been decided to erect the Observatory on this site, and to rebuild the lighthouse and telegraph station at the same time. The new Observatory will be about three miles west of the present building and about two huudred feet above the level of the sea. The site is favourable for astronomical and meteorological observations ; it has the great advantage of security against being built around, or of being required for other purposes, and it is but little over a mile from the upper portion of the Birkenhead Docks. The new Observatory will be placed close to one of the stations on the line of electric telegraph between Liverpool and Holyhead, which line is the private property of the Mersey Docks and Harbour Board, and it is thought that great practical advantages will be derived from this arrangement. The plans for the new building have been decided on, and Mr. Hartnup hopes to be established in the new Observatory by the latter part of the approaching summer.

Edinburgh Observatory.

Owing to the absence of the Astronomer Royal for Scotland upon a scientific expedition to Egypt, no Report of this Observatory has been received.

Glasgow Observatory.

At the Glasgow Observatory, the astronomical operations during the past year have been of the usual routine character. The Transit Circle, which carries a telescope of 6 French inches aperture, has recently received some important improvements which have very much increased its efficiency. A new eye-piece of the same construction as the eye-piece of the Greenwich Transit Circle has been applied to the telescope by Troughton and Simms ; new micrometer microscopes have also been executed for the instrument by the same makers. The effect of these alterations, judging from the results of actual observation, has been most satisfactory. The Equatoreal has been employed during the past year in observations of the minor planets and comets, and occasional observations of double stars. A batch of observations of the minor planets has been recently forwarded to Professor Peters for publication in the *Astronomische Nachrichten*. The negotiations and arrangements connected with the transmission of correct time to the city of Glasgow and the shipping of the Clyde still continue to occupy much of Professor Grant's attention. The results of Jones's invention have so far been eminently successful.

There are at present ten public clocks in the city of Glasgow controlled by a current of electricity from the normal mean time clock of the Observatory, at an average distance of three miles from the controlling source. The University, the Exchange, and the Town Council, have availed themselves of the advantages which the Observatory offers in this respect. The Clyde Trustees have also decided upon establishing controlled clocks upon both sides of the river in behalf of the shipping interest, and steps are now being taken for laying down a new electric wire in furtherance of that object.

Kew Observatory.

Mr. Balfour Stewart, Director of the Kew Observatory, reports:—

The Kew Heliograph has continued in constant operation, under the direction of Mr. Warren De La Rue, and at least two pictures of the Sun's disk have been taken on every day when this was possible. The instrument has been worked by a qualified assistant, under the immediate superintendence of Mr. Beckley. During the year 1864, 250 pictures have been taken on 170 days.

Mr. De La Rue has profited by the engagement at Kew, for specific objects, of Mr. B. Loewy, formerly assistant at the Melbourne Observatory, to make an arrangement with that gentleman for his aid in measuring and reducing the observations made with the Kew Photo-heliograph. This arrangement has greatly contributed to the progress of the work, and as a first result, the first two of a series of papers on the Physics of the Sun have just been communicated to the Royal Society by Mr. De La Rue, Mr. Stewart, and Mr. Loewy, jointly.

In the first of these, after a few preliminary remarks on the history of the subject, these gentlemen have endeavoured to answer the following questions:—

1. Is the Umbra of a spot at a lower level, that is, nearer the centre of the Sun, than the Penumbra?
2. Is the luminous matter of the Sun of the nature either of a gas or cloud, or is it heavy liquid or solid matter?
3. Is a Spot (including umbra and penumbra) below the level of this luminous matter or above it?

With reference to the first of these, it was shown from the Kew pictures that in the great majority of cases the Umbra of a spot encroaches on the Penumbra on that side of the latter which is nearest the visual centre of the disk, from which it was argued that the umbra is at a lower level than the penumbra.

In answer to the second question, it was argued that the reason why Faculæ near the limb of the Sun appear relatively much brighter than the surface around them is, that they are

elevated above the grosser portion of the solar atmosphere, thereby escaping its absorbing effect, which is very strong near the border; and it was remarked that Mr. De La Rue had obtained stereoscopic impressions of a spot in which the faculæ appeared as elevations.

It was, therefore, argued that faculæ are portions of the luminous matter which have been elevated, and it was observed that they retain nearly the same appearance for days together, it was therefore supposed that this luminous matter is more of the nature either of a gas or cloud; other considerations rendering it more probable that the luminosity is due to small particles of solid or liquid matter in suspension, namely, a cloud.

With reference to the third question, it was shown that in the majority of cases the faculæ accompanying a spot are to the left of the spot, as if the luminous matter had been abstracted from the surface occupied by the spot, and being carried upwards into a region possessed of greater absolute velocity of rotation, had in consequence fallen behind.

It was also stated that sometimes luminous ridges, unaccompanied by any penumbra, and sometimes detached portions of luminous matter, move across a spot.

From all this it was argued that a spot is below the level of the luminous matter, and is, in fact, a hollow or cavity extending into the regions beneath the photosphere.

In conclusion, the authors propose the following question:—

May not the falling behind of faculæ be the physical reaction of the proper motion observed by Carrington, so that, while the current passing upwards falls behind, carrying the luminous matter with it, the current coming down moves forward, carrying the spot with it, and may not this latter current coming from a colder region account for the deficient luminosity which characterises a spot?

In the second of these papers it was remarked that, generally speaking, all spots which appear on the Sun's surface about the same time behave in the same manner.

For instance, if one spot increases to the central line or past it, another will do the same; if one spot diminishes from its first appearance, another will do the same; if one spot breaks out on the right half, another will do the same. It was argued that the only probable explanation of this is, that the behaviour of spots is affected by some influence from without.

Let us, for instance, imagine that the influence is one unfavourable to the production of spots, and that at first the Earth and this influence are in conjunction in respect of the Sun. There will evidently be a minimum of spots at the visual centre of the solar disc, as the surface there is in the immediate neighbourhood of the influence, which is imagined to be unfavourable to the production of spots.

Now, two cases may be supposed. 1st. The Earth moves faster than the influence supposed unfavourable to the formation of spots. 2nd. The Earth moves slower than this supposed influence.

Case the 1st. The following will be the sequence of phenomena:—

(1st.) At conjunction, or a little after it, spots form mostly on the right side;

(2nd.) As the influence is left behind, in consequence of the Earth's faster motion, spots form to the left and *increase* as they approach the *right* (west) limb.

Case the 2nd. But if the influence move more quickly than the Earth the following will be the sequence of phenomena:—

(1st.) At conjunction, or a little before it, spots form mostly on the right side, as before;

(2nd.) As the influence has passed to the right, spots *decrease* as they approach the *right* limb.

By making use of all Mr. Carrington's pictures and all the Kew pictures, it was shown from a ten-years' series that the latter is the order followed, and, consequently, that the influence moves faster than the Earth.

Finally, it was shown that the influence, or rather predominant influence, appears to be exerted by *Venus* in such a manner that, as spots approach the neighbourhood of this planet by rotation, they decrease; but as the solar surface departs from this neighbourhood, it tends to break out into spots which reach their maximum on the opposite side. Of course, it is not supposed that *Venus* is the cause of the ten-yearly period of spots.

A micrometric scale has been attached to Mr. De La Rue's measuring instrument, by means of which the amount of spotted surface may be accurately measured; and arrangements have also been made for measuring the spotted surface in Carrington's original drawings, which have been kindly lent for this and other similar purposes.

Scientific Balloon Ascents.

In the Report for the year 1863, reference was made to the results of the then Balloon experiments, eight in number, made by our colleague, Mr. Glaisher, indicating that the hypothesis of a diminution of 1° Fahr. of temperature, for every additional 300 feet of elevation, must be abandoned. Since that time, sixteen additional ascents have been made; some of these in the depths of winter, and others in almost every month of the year. In the winter ascents a higher temperature has been met with than on the earth; in the summer at the time of sunset, no difference of temperature has been experienced for

2000 feet from the earth ; the general results are, that the law of decreasing temperature with elevation, varies with the season of the year ; and it seems probable that the law which holds good during the day may not hold good during the night.

Mr. Glaisher is now preparing for night ascents, and hopes to collect definite information as to the increasing or decreasing temperature at night, for it seems probable, that—as there is a decrease by day, which is checked before sunset, ceasing at this time—so for some little distance from the Earth, there may be an increase at night.

The bearing of all the experiments made on the theoretic determination of atmospheric refraction is, that every observatory will have to determine whether the same coefficient of refraction holds good by day and by night.

Mr. De La Rue's Observatory.

The results of the reduction of the observations made with the Kew Heliographs have induced Mr. De La Rue to turn his attention to simultaneous eye-observations of the Sun with adequate instruments; he has therefore during the past year been in a great measure engaged in adapting his 13-inch reflector for such observations. In the first place, a Herschelian prism was substituted for the ordinary diagonal reflector, but it was subsequently found to be absolutely necessary to replace the old tube with a skeleton tube, containing the least possible amount of material consistent with rigidity. This was effected by making the tube of gas-pipes one inch in diameter, inserted through sockets, screwed on to rings, the whole being further strengthened by tension bars, formed of wire, $\frac{1}{8}$ of an inch in diameter, drawn tight by screws.

In the Observatory of Mr. Huggins, at Upper Tulse Hill, researches on the application of prismatic analysis to the light of the heavenly bodies have been carried out during the past three years. The principal results of these observations were communicated last year to the Royal Society in two papers: the first paper, in May, entitled "On the Spectra of some of the Fixed Stars," by Mr. Huggins and Prof. W. A. Miller ; and the second paper in September, "On the Spectra of some of the Nebulæ," by Mr. Huggins.

In the former paper Mr. Huggins and Prof. Miller describe a form of spectrum apparatus, by which the lines in the spectra of the heavenly bodies can not only be measured with great accuracy, but also the positions of those lines, with reference to the bright lines of terrestrial elements, can be determined with great precision, by means of a simultaneous comparsion of the two spectra seen in juxtaposition.

By this method of direct comparison with the light of terrestrial flames, they examined the spectra of the Moon, *Venus*, *Mars*, *Jupiter*, and *Saturn*, and about fifty of the fixed stars.

The results of the examination of the light from the Moon and *Venus* are as yet negative.

The spectra of *Jupiter* and *Saturn* contain absorption lines, which show that the atmospheres of these planets, though similar to our own, are not identical with it in constitution.

The atmosphere of *Mars* is of a different composition.

Aldebaran gives a spectrum containing lines which indicate in that star the presence of hydrogen, sodium, magnesium, calcium, iron, bismuth, tellurium, antimony, and mercury.

In the spectrum of *α Orionis*, about 80 lines have been measured. This star probably contains sodium, magnesium, calcium, iron, and bismuth. Amongst some fifty stars which have been examined, two stars, *α Orionis* and *β Pegasi*, are remarkable for the absence in their spectra of the lines of hydrogen, corresponding to the lines C and F of the solar spectrum, which lines are strong in the spectra of all the other stars.

The elements which were found most widely diffused through the host of stars are some of those most closely connected with the living organisms of our globe, including hydrogen, sodium, magnesium, and iron.

These observations support the conclusion that the stars have a physical constitution analogous to that of our Sun, and, like it, contain several elementary forms of matter which enter into the composition of the Earth.

The spectra of the components of *β Cygni*, and of some other dichromic double stars, were found to differ greatly from each other in the positions of the lines of absorption. These and some other observations suggest that the source of the difference of colour observable among the stars is to be found in the difference of chemical constitution of their atmospheres. Each constituent will produce its own group of absorption lines, and the position of these groups in the spectrum will determine the colour which will preponderate in the star's light.

In August last, Mr. Huggins, now working alone, applied this new method of research to several of the Nebulæ.

The small intensity of the light of these objects would probably have prevented the attainment of any definite results, if, to Mr. Huggins's great surprise, he had not found the light of many of them to consist of three definite refrangibilities only. The light from these nebulæ, after passing through the prisms, remains concentrated into three bright lines. Such a spectrum is known to be emitted only when matter in *the gaseous state* is rendered luminous by heat. The positions in the spectrum of these bright lines indicate with great probability the presence in these nebulæ of hydrogen and nitrogen, together with a third substance at present unrecognised.

The nebulæ which have been found to give a similar spectrum of bright lines characteristic of *gaseity* are—37 H. iv., 6 Σ., 73 H. iv., 51 H. iv., 1 H. iv., 18 H. iv., the Annular Nebula in *Lyra*, the Dumb-bell Nebula, and the Great Nebula in the sword-handle of *Orion*.

In the case of 37 H. iv. and 73 H. iv., the light of the bright central point differs from that of the Nebula, and gives a continuous spectrum.

It is obvious that these Nebulæ can no longer be regarded as clusters of stars, but as enormous masses, or systems of masses, of luminous gas.

The following clusters and nebulæ give a continuous spectrum :—92 M., 50 H. iv., 26 H. iv., 55 *Andromedæ*, 15 M, 2 M, the great nebula in *Andromeda*, and the companion nebula, 32 M.

Mr. Huggins is preparing to carry on these investigations with the aid of a large silver-on-glass speculum, which will collect much more light than the 8-inch refractor he has hitherto employed.

Mr. Birt is engaged in the formation of a Catalogue of Lunar Objects with the view of accumulating data for the production of a map, in which the more minute details may be accurately determined and inserted. Under the auspices of the British Association for the Advancement of Science, forms have been prepared for the determination and reception of such particulars as may assist in the ready identification of even the most minute point, a distinct symbol of reference being appropriated to each object.

He is also pursuing his observations, both at Hartwell, with the Equatoreal of 5·9 in. aperture, and in London, with the Royal Society's achromatic of $4\frac{1}{4}$ in. aperture, with especial reference to this work, in which the photographs of Mr. De La Rue are found of great assistance.

Progress of Astronomy during the past Year.

No additions of any great importance appear to have been made during the past twelve months to Astronomy in its mathematical aspect. When, however, we reflect that since the days of Newton the most powerful minds of successive generations have brought all the resources of geometry to bear upon the interpretation of Celestial Mechanics, and that at the present time the mathematical theory follows so closely on the heels of observation, that the reading of the Moon's theoretically tabulated place, thanks to Hansen and to Greenwich, is equivalent in accuracy to a single instrumental observation; while in

the hands of Leverrier the theories of *Mars* and *Venus* have alone been sufficient to indicate an amendment of the Earth's reputed distance from the Sun, it must be expected that any great improvement in the mathematical theory of Astronomy must be extremely difficult and slow. This remark is not made in the spirit of apology; it rather suggests a ground for patience.

On the other hand, the relation between terrestrial physics and the physics of the sidereal heavens is rapidly becoming more intimate, the boundary line once supposed to divide them is gradually disappearing, while new and unexpected fields open for the application of results of experimental philosophy, in distant regions of space, where formerly they were supposed to have little or no concern. The telescope, also, is receiving enormous additions, both to its grasp of light and to the accuracy of its optical powers. It is under these promising circumstances, and partly influenced by their existence, that Sir John Herschel has opportunely given to the scientific world his work upon the Nebulæ, which will for ever make the year 1864 memorable in the annals of Astronomy. Up to that date no general and complete catalogue of the Nebulæ was in existence. The observer was compelled to search through a diversity of memoirs scattered among the volumes of learned societies, and even then the places of these celestial systems being arranged upon no uniform plan, and not reduced to any common epoch, the observer was for a time left in doubt as to the nature or originality of the phenomenon which appeared in the field of his telescope. In this way, "A great many Nebulæ have been from time to time, in the *Astronomische Nachrichten* and elsewhere, introduced to the world as new discoveries, which have since been identified with Nebulæ already described and well known. Many a supposed comet would have been recognised at once as a Nebula, had such a general catalogue been at hand, and much valuable time been thus saved to their observers in looking out for them again."* To remedy this inconvenience, and to promote the advancement of this branch of Astronomy, Sir John Herschel, for many years past, has applied himself to the formidable task of making a complete catalogue of all the Nebulæ and clusters of stars actually known, both Northern and Southern, arranged in the order of right ascension, and reduced to the common epoch of 1860, so that the places being determined for that date, and the annual precession being given for twenty years in advance, there can easily be obtained trustworthy positions for any year up to 1930. For the due execution of this work, Sir John was provided with means—they can scarcely in such a case be called facilities—in the possession of no other astronomer. Not only had by far the greater number of these Nebulæ been

* *Phil. Trans.* vol. 154, Part i. p. 2.

for the first time observed by himself, but he possessed the draughts of all his Father's observations, and especially and notably a MS. Catalogue of all the Nebulæ and clusters observed by Sir William Herschel, arranged in zones, and reduced to the common epoch, 1800, by the personal labour of Miss Caroline Herschel. Even then it was necessary, as a preliminary step, to reduce this catalogue to the more advanced epoch of 1830, and to re-arrange it in the order of right ascension, before it could afford the means of comparing or identifying the objects it contained with those observed at a later period by Sir John Herschel himself. This labour, in itself enormous, was executed by Sir John's own hands, with no further assistance beyond that afforded by his own sons. This comparison effected, involving as it did cases of intricacy and difficulty, necessitating a perpetual recurrence to the original sweeps and to other documents, it became necessary to re-copy the whole ten thousand entries (for such is the number, taking both the elements), in order that the catalogue might be placed in the hands of a professional computer (Mr. Kerschner), for the reduction of the whole to the more advanced epoch of 1860.

Towards the completion of this laborious undertaking, a Catalogue of Sir William Herschel's Nebulæ, reduced to the epoch of 1830, and arranged in the order of R.A. by M. Auwers, was placed in Sir John Herschel's hands. Of the ability with which this work has been conducted by M. Auwers Sir John speaks in the handsomest terms, but it can scarcely possess an equal amount of authority with his own, for want of the original sweeps and other documents referring to the observations, which could not be accessible to the former astronomer. The possession of this able work of M. Auwers necessitated a careful scrutiny and comparison of the two catalogues, resulting in the expurgation of many errors from both.

It is scarcely advisable to enter into any further details regarding the composition of this remarkable work, they are sufficiently set forth in the preface to the Catalogue contained in the volume for 1864 of the *Philosophical Transactions.* Whoever consults the original will inevitably be struck with the completeness, and the condensation of the information which it conveys; nor will the modesty of the bulk of this great catalogue escape him—a compactness brought about by compressing by means of ingenious but expressive abreviations a lucid and complete description of the physical character of every object, into the space of a single line of two inches. With peculiar thoughtfulness there is added a list of all the Nebulæ of which figured representations are known to have been published, and the Catalogue terminates with a supplementary list of twenty-two Nebulæ, recently observed, fifteen of which were contributed by Professor Bond, but too late to be embodied in the general text.

Thus has come forth to the astronomical world a work

wherein it is difficult to say whether marks of sagacity or of labour most abound. Of the 5000 celestial objects which it describes, incomparably the greater number bear the initials of the two Herschels; not only were they discovered, computed, reduced and catalogued by these two astronomers, aided indeed by a lady bearing the same illustrious name; but the very instruments (marvels of construction in their day) by which they were discovered, were made by their own hands. In this way has been completed a task, which we can best describe in the language similar to that applied by Sir John himself to the sister of Sir William Herschel; "a task which only the most boundless devotion could have induced him to undertake, or enabled him to accomplish."

Analysis of Light from the Nebulæ.

It is to the ingenuity and perseverance of Mr. William Huggins that, within the last few months, we are indebted for the first glimpse of our knowledge of the constitution of the mysterious systems of matter which have formed the subject of the foregoing remarks. Until these investigations it was not possible to hazard more than a plausible guess whether the Nebulæ were systems of stars too remote, to admit of telescopic resolution, whether the planetary Nebulæ were collections of cosmical matter in process of condensation into systems of worlds, or whether they were enormous wisps and patches of vapour floating on, to us, the remotest visible confines of space. To a certain extent, and consistently with the present imperfect state of our physical knowledge, Mr. Huggins's investigations present us with a probable answer to one or two of these questions.

It is well known, through the researches of late years, that by prismatic refraction of light, it is possible to determine very much of the nature of the source from which it emanates. If the luminous source be an incandescent solid, or liquid body, the spectrum is continuous, but if the source of light be in the form of a vapour or a gas, the spectrum consists only of detached bands, or lines of colour, the relative positions of which are generically different for different substances, insomuch that it is generally possible to detect these substances individually, by means of the analysis of the light from their flames. Further still, the vapours of these substances absorb or extinguish rays of the same refrangibilities which they emit when luminous, each after its kind. This mode of analysis had, to a partial extent, been already applied to the light emanating from some of the stars by Fraunhofer, Donati, and others, before Mr. Huggins and Professor W. A. Miller commenced their own researches on a much more complete and systematic plan. The results of their labours have been recorded in two very

remarkable papers contained in the *Philosophical Transactions for* 1864. It may be sufficient here to note, among others, the following striking deductions:—

1. That the photospheres of the stars contain the vapours of many of the same materials as those existing in the crust of the earth, namely, hydrogen, sodium, magnesium, iron and other elements.

2. That the colours of the stars are owing to the partial absorption by the vapours of their photospheres of some of those colours which are different from, or complementary to, the colours wherewith they actually shine to us. From this it follows that a red star is not necessarily in a state of lower incandescence than a blue star.

3. That probably no atmosphere of appreciable extent surrounds that portion of the Moon which is visible to us.

4. That the planets *Mars*, *Jupiter*, and *Saturn*, are provided with atmospheres containing the vapours of some substances not in our own atmospheres nor in the envelope of the Sun's photosphere.

Some of these results are, to say the least, unexpected, but they afford us some logical ground for concluding the existence of a community of matter, and, generically, a community of design throughout the entire sidereal system.

As soon as the first stage of these researches was thus brought to a successful termination, Mr. Huggins, by a happy thought, directed his telescope and its prismatic adjuncts to some of the planetary Nebulæ, with the view of interrogating these mysterious systems as to their physical conditions. Are the nuclei visible in some of these wonderful masses, solids? Are the fleecy filamentous rings which surround them, vapours? or are they aggregations of stars inconceivably remote?

The replies to these questions are contained in the forms of the prismatic spectra which they exhibit. Briefly the results are these. The spectra of most of the planetary Nebulæ observed by Mr. Huggins are nearly identical: they consist mostly of three detached lines, accompanied, when the nebula possesses a visible nucleus, with a very faint continuous spectrum. The detached lines indicate gaseous substances, two of them probably nitrogen and hydrogen, and the third some element unknown. The faint continuous spectrum was proved to belong to the nucleus, and indicates the existence of some amount of solid or liquid materials. Besides the planetary nebulæ, those remarkable objects, the annular Nebula in *Lyra*, and the Dumb Bell Nebula, were examined and proved to have a similar gaseous constitution, while the Great Nebula in *Andromeda* gives a continuous spectrum, indicating the presence of solid or liquid incandescent matter.

Since the foregoing paragraphs were in type, Mr. Huggins has given to the Royal Society the results of the prismatic

analysis of the Great Nebula in *Orion*. He has examined with special care the brighter parts of the nebula adjacent to the trapezium, with the view of ascertaining whether the brighter light of these portions emanates from clustering stars, or from gaseous matter alone. Lord Rosse and Professor W. C. Bond have described these portions as consisting of stars, but the results of Mr. Huggins's investigations with the prism is that, inasmuch as the spectra of these portions of the nebula consist of three bright lines alone, the light proceeds from gaseous, vapoury matter, and not from consolidated stars. All parts of this great nebula emit light which is identical in its prismatic characters, the light of one part differing from that of another in intensity alone.

The thanks of all persons interested in the progress and results of astronomical science (and who is not?) will be readily accorded to Mr. Huggins and Professor W. A. Miller for their investigations in this most fascinating branch of Sidereal Physics.

M. Donati (Analysis of Cometary Light).

Apparently in close analogy with the foregoing observations of the nebulæ, are the results obtained by M. Donati upon applying prismatic refraction to the light emitted from Comet I., 1864. "The spectrum of this Comet," says M. Donati, "resembles the spectra of the metals; in fact, the dark portions are broader than those which are more luminous, and we may say these spectra are composed of three bright lines." So far, then, there is reason to presume the existence of some close relation between nebulous and cometary matter. Thus another step is gained in our knowledge of Sidereal Physics.

Luminous Meteors.

A few years ago our exact knowledge of these mysterious fiery showers was confined mainly to the observation of their periodical recurrence on certain nights in August and November: other meteoric phenomena being supposed to be reducible to no law. The recent labours of Messrs. Greg and Alexander Herschel in this country, and of Messrs. Newton, Quetelet, Heis, Secchi, and others abroad, have contributed very much towards bringing some of the phenomena of meteors as much within the domain of astronomical science, as are the orbits and periodical returns of Comets. The following brief summary will serve to explain the present state and the recent advances of this branch of natural science:—

1. Fifty-six radiant points of shooting stars have been determined. That is to say, at fifty-six known epochs in

every year luminous meteors may be expected to be visible, proceeding in greater or less abundance from certain definite positions in the heavens, which radiant points are in general denoted by proximity to, or allineations from, the positions of certain stars.

2. The compact group of meteors producing the well-known star-showers of the 12th to the 13th November, circulates round the Sun from node to node in 354·621 days, in an orbit nearly circular, retrograde, inclined at 17° to the ecliptic, and with a retrograding node. The Earth is immersed in the margin of this meteoric group at the intervals of a third part of a century, and central immersions take place once in every 133 years. The next marginal immersion will take place in 1866, Nov. 13, G.M.T. 21^h, and be chiefly visible in the Western Atlantic, after which the meteors will remain invisible until the next immersion in 1899; which will be central.—*American Journal of Science*, July, 1864.

3. The average height of shooting stars is 73 miles above the surface of the Earth at their first appearance, and 52 miles at disappearance: the probable error not exceeding three miles.

4. The average velocity of shooting stars, concluded from 66 instances, is 35 miles per second. If they arrive within 20 miles of the Earth's surface there is in general a violent concussion and precipitation of stony matter.

5. All meteoric stones bear evidence of having once formed portions of larger rocks: their velocity is too great to be within any ballistic power of terrestrial or (if such exist) of lunar volcanic action. The conjecture forced, at present, upon the minds of those who have most studied the subject is, that parent planets in some unknown quarter, too small and powerless to reclaim their own fragments, have scattered these stony masses ("pocket planets," as they are termed by Humboldt) into space, and they now circulate round the Sun in such countless numbers as to strike the Earth almost daily in its path. Thus the well-directed, patient labours of a few able observers have brought these nightly showers of fiery dust away from the regions of superstition and terror to the domain of calm admiration and intelligent inquiry.

Physical Structure of the Sun's Photosphere.

Mr. De La Rue and the observers at Kew have recently employed themselves in a careful examination of the pictures of Sun-spots, as obtained by the Kew Heliograph and from Mr. Carrington's maps, and they have arrived at the following conclusions:—

1°. Sun-spots are cavernous; they lie below the general level of the Sun's luminous matter, and extend into the regions beneath it;

2°. The faculæ are portions of the Sun's luminous matter elevated above the general level of the photosphere; and near the limb of the Sun they appear relatively brighter than the surrounding surface, because on account of their greater elevation, the light which they emit is less subject to absorption by the Sun's atmosphere;

3°. The Sun's luminous matter is of the nature of cloud;

4°. The formation of Spots on the Sun is, in some way, influenced by the planet *Venus*.

Sidereal Chromatics.

Admiral Smyth, in "a Reprint with Additions, from the *Bedford Cycle*," has recently proposed a series of coloured discs as standards of comparison for the colours of multiple stars, and he has produced strong evidence of a very marked and periodical change of colour in the double star 95 *Herculis*, one of its components changing in twelve years, from "yellow," through "grey," "cherry red," and "egregious red," to yellow again. According to our present knowledge, this change of colour indicates physical changes, either in the incandescent materials of the stars themselves, or in the vapours of their photospheres! A new field of research in Sidereal Physics has thus arisen; but the veteran astronomer, who calls attention to the phenomena, expresses a caution and a hope that the fascinating novelty of the inquiry will not detach competent men from the GEOMETRY and DYNAMICS of pure ASTRONOMY.

Celestial Photography.

With one important exception, nothing of a very novel or marked character appears to have been produced in astronomical photography. Messrs. Draper and Rutherford, U.S. are actively engaged upon the subject with large instruments specially constructed for the purpose.

The exception alluded to in the preceding clause refers to the large photograph of the Moon recently completed by Mr. De La Rue. The dimensions of this lunar autograph are the same as those of Madler's Map, viz. three feet two inches in diameter. A very few copies of this remarkable production have been distributed, and, in particular, copies have been presented to the Royal Astronomical Society and the French Academy. M. Leverrier has applied to this photograph the very appropriate expression, "Magnificent!"

Mr. Lassell's Observations at Malta.

A summary of the important results of Mr. Lassell's devoted self-banishment to Malta, for the advancement of Astronomical Science, is given in the form of a letter appended to this Report. It will be sufficient here to indicate, that in addition to the discovery of many Nebulæ heretofore unobserved, and the careful re-delineation of others observed in England under less favourable atmospheric circumstances, and with telescopes of far less optical power, Mr. Lassell, after the most careful scrutiny, comes to the conclusion, that the number of the known satellites of *Uranus* must be reduced from eight to FOUR, and those of *Neptune* from two to ONE.

Optical Tables for Aplanatic Object-glasses.

Mr. Pritchard has completed a set of Tables, whereby the practical optician may, by very little more than simple inspection, obtain the forms of lenses producing aplanatic combination for the object-glasses of telescopes. The artist may at the same time watch the march of the spherical aberration, arising from variations in the curvatures and materials of the lenses employed. For executing the numerous and laborious interpolations in these Tables, assistance has been accorded from the Government Grant Fund at the disposal of the Royal Society.

New Astronomical Instruments.

Messrs. Troughton and Simms have, in the course of the past year, completed an Equatoreal for the Madras Observatory, in which they have introduced an improved method of adjusting the instrument to position. It is accomplished by means of two screws, so arranged that the position of the polar axis in its bearings, which are "segmental," shall be undisturbed by the operation.

Mr. William Simms has improved the double-image micrometer by the addition of a fifth lens. At the point where an image of the object-glass is formed by the first lens, a negative lens is placed; and close to it, so as to form a positive combination, the newly introduced glass is fixed. An eye-piece is in effect formed, of the same character as the eye-piece of four lenses, whilst the advantage obtained by having a concave divided lens is retained. A micrometer thus arranged has been sent to Madras with the Equatoreal.

A little addition has been made to the Transit Reducer, invented by Professor Challis, which renders it available to a considerable range of latitude. The instrument thus modified becomes of considerable use in a survey, where the position of the observatory is constantly changing.

Improvements of a minor character, generally consequent upon the introduction of a superior class of tools, have been made in other instruments; the only one which we think it necessary to mention, is a method of making the hollow conical supports for the horizontal microscopes of an Altazimuth, of one piece of metal with each other and with the ring which carries them, thereby avoiding various sources of instability which have always hitherto been suspected to exist in instruments of that class.

Mr. Cooke is engaged in the construction of a Refracting Telescope of very uncommon dimensions. The aperture of the object-glass is 25 inches, with a focal length of 29 feet. The Equatoreal mounting is on the German plan; and the tube is of steel. For the formidable task of figuring the lenses, Mr. Cooke has invented machinery, which combines exquisite simplicity with efficiency and economy. Astronomers will watch the progress and completion of this truly gigantic refractor with great interest, not to say with some anxiety. The time has happily come when English instrument-makers find it advantageous to combine in the same establishments the machinery and massive appliances of the engineer with the delicate tools and manipulation of the optician.

Southern Survey.

No account of progress was contained in the last Annual Report, as preliminary correspondence was still going on, but it may now be stated with some confidence, that the arrangements proposed to three Southern Observatories are accepted by their respective directors, and are likely to be carried out with such despatch as they may be able to command. A corresponding division of the hemisphere into zones for mapping and publication has been resolved on, namely:—

Zone	1	Equ.	to	20° S.
	2	20° S.		40°
	3	40°		60°
	4	60°		80°
	5	80°		Pole.

The subsisting plan is, that Mr. Pogson at Madras commences with Zone 2, and when that is completed, or nearly so, follows on with Zone 1; that Mr. Ellery at Melbourne shall successively take up Zones 4 and 3; and that Sir T. Maclear, after a preliminary survey and mapping of the 5th Zone, will proceed to the more exact observation of this polar section, and the formation of a Catalogue corresponding to the Redhill Catalogue for the north.

In the matter of reducing former Catalogues to the epoch 1875·0, Mr. Pogson has charged himself with the application

of precession to Taylor's Madras Catalogues, and Mr. Carrington has charged himself with the same process in respect of Weisse's Catalogue of Bessel's stars from the equator to 15° S. containing about 13,000 places, and of Oeltzen's Catalogue of Argelander's stars from 15° to 31° S., containing about 18,000 separate places. The Government Grant Committee have recently voted him 90*l.* for the purpose, and an efficient computer is engaged and making rapid progress. As a precaution against loss in transmission, press copies are taken of every sheet of figures, which will be retained in this country.

In another year we may hope to report so many component sub-zones as observed, reduced, and written out at each Observatory, and estimate better what success is likely to attend this attempt to survey the Southern hemisphere on the principle of co-operation.

Direct Vision Spectroscope.

Mr. Alexander Herschel has invented a very simple but remarkably ingenious Spectroscope. It consists of two right-angled prisms of dense glass, so placed that by means of four internal reflections, the observer's eye is turned directly towards the source of light. Its dispersive power is so considerable that the duplicity of Fraunhofer's line D is visible with an optical power of five. The most acute angle (A) of each prism is determined by

$$\sin 2A = 1 - \frac{1}{\mu^2}.$$

The President's Soiree.

It has not hitherto been the custom for the members of the Astronomical Society to assemble and meet their friends and members of other learned bodies; but after the lapse of many years the time appeared to have arrived when it might be advantageous for such an assembly to take place, to which could be exhibited the remarkable advance made in the construction of astronomical instruments in recent times. The rooms of the Society being inadequate for such a gathering, it was arranged that it should take place at Willis's Rooms, wherein, through the liberality of the President, Mr. De La Rue, about 500 members and guests met together and enjoyed an opportunity of inspecting a collective array of instruments such as has never before been exhibited. The fitting opportunities for such assemblies can of course occur but rarely and at distant intervals.

Papers read before the Society from February 1864 *to February* 1865.

1864.

Mar. 11. On the Parallax of the Sun. Mr. Finlayson.
On the frequent Omission of Readings of the Barometer and Thermometer in Sextant Observations for the Determination of Latitude and Longitude. Mr. Dunkin.
List of New Double Stars. Rev. W. R. Dawes.
On the Willow-Leaves of the Sun. Mr. Stone.
On Meteorolites. Mr. A. Herschel.
On a Passage in Captain Jacob's Measures of *Jupiter* and his Satellites with the Madras Equatoreal. Mr. Airy.
On early Observations of *Uranus* by Bradley. Mr. H. Breen.

April 8. On the Companion of *Sirius*. Mr. Lassell.
Comparison of the Chinese Record of Solar Eclipses in the *Chun Tsew* with the Computations of the Modern Theory. Mr. Airy.
Observations of N.P.D. of the Moon and Stars from 1856 to 1859. Sir T. Maclear.
Note respecting his List of Double Stars. Rev. W. R. Dawes.
On the Willow-Leaves of the Sun. Rev. W. R. Dawes.
On the Companion of *Sirius*. Rev. W. R. Dawes.
On Meteorology. Mr. A. Herschel.
Notes on Occultations of Stars by the Moon. Capt. Noble.

May 13. Notes on α *Centauri*, &c. Mr. Powell.
On the Boundary Forms of the Bright Patches on the Sun's Disc. Mr. Drach.
On the Appearances on the Sun's Disc. Mr. Talmage.
On Dr. Steinheil's Stellar Spectroscope. Mr. Lettsome.
On the Astronomy of the Ancient Egyptians. Mr. Bonomi.
List of Radiant Points of Shooting Stars. Mr. A. Herschel.
On the Transit of *Venus*, 1882, Dec. 8. Mr. Airy.
On the Satellite of *Sirius*. M. O. Struve.
Determination of the Sun's Equatoreal Horizontal Parallax, &c. Mr. Stone.

On the Number of Meteors in March. Mr. A. Herschel.
Results of Recent Observations on the Solar Surface. Rev. W. R. Dawes.
On the Probable Error of a Meridional Transit by the Eye-and-Ear and Chronographic Methods. Mr. Dunkin.
On the Planet (76) *Freia*. Mr. Pogson.
On the Alteration of Factors for Level and Azimuth Corrections of a Transit due to a Change of Latitude. Rev. C. Pritchard.
Errors in his Logarithms. Gen. Shortrede.

June 10. On certain Suspected Changes in Moon's Surface. Rev. T. W. Webb.
On the Large Sun-Spot Period of 56 years. Mr. Stewart.
On the Nebula in *Orion*. Professor Bond.
On the Willow-Leaves in the Sun. Mr. De La Rue.
Solar Eclipses observed in China. Mr. Williams.
Observations at Malta. Mr. Lassell.
On μ *Herculis*. Rev. W. R. Dawes.
On the Bright Border of the Moon's Limb in Photographs of Eclipses. Mr. Airy.
On a Zenith Sector. Lieut.-Col. Strange.
On the Achromatic Object-Glass. Mr. Hodgson.
On the Method of Determining Heights in the Trigonometrical Survey of India. Col. Walker.
On the Star β *Leonis*. Mr. Knott.

Nov. 11. On a New Form of Thermometer. Mr. Hamilton.
Radiant Points of Shooting Stars. Mr. A. Herschel.
Discovery of a Comet in Australia. Mr. Tebbutt.
Description of the Observatory at Bonner's Hill, Quebec. Lieut. Ashe.
On the Bright Band bordering the Moon's Limb in Solar Eclipses. Professor Challis.
Meteoric Appearances of the Sun's Surface. Mr. Brodie.
Address at the Opening of the Session 1864–5. Mr. De La Rue.
On the Forms proposed by Sir J. Herschel and Gauss for the Aplanatic Object-Glass. Rev. C. Pritchard.
On the Variations of the Moon's Place produced by the Motion of the Ecliptic. Mr. Penny.
Remarks upon the Aplanatic Object-Glass. Mr. J. Simms.
On a New Binocular Telescope. Mr. Watson.

Dec. 9. Opposition of *Mars*, 1864. Mr. Joynson.

Observations and Elements of Comet I., 1864. Mr. Tebbutt.

On the Orbit of *Sirius*. M. Auwers.

Occultation of $\varkappa$ *Aquarii*. Mr. Talmage.

Sur le Diamètre apparent de *Sirius*. M. Chacornac.

On Solar Spots. Rev. F. Howlett.

On the Accuracy of the Fundamental Stars of the Greenwich 7-Year Catalogue of 1860. Mr. Stone.

Variable-Star Nomenclature. Mr. Chambers.

1865. Occultation of $\varkappa$ *Aquarii*. Captain Noble.

Jan. 13. On the Mean Velocities and Areas described by the Radii Vectores of Planets in their Orbits. Mr. Finlayson.

On the Determination of the Error of Excentricity in a Sextant. Major Tennant.

Observations of Comets II., V., and VI., 1863. Mr. Hartnup.

Approximate Ephemeris of Encke's Comet. Mr. Farley.

Comparison of the Transit Instrument in its ordinary or reversible form with the same in its non-reversible form, as adopted at Greenwich, Cape of Good Hope, &c. Mr. Airy.

Determination of the Semidiameter of *Venus* at the Mean Distance of the Sun from the Earth. Mr. Stone.

On the Appearance of the Spectrum of ε *Piscium* at its Occultation of January 4, 1865. Mr. Huggins.

On the Nebulous Star 45 $\frac{H}{G}$ IV. *Geminorum*. Mr. Knott.

List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

Her Majesty's Government.
The Lords Commissioners of the Admiralty.
Royal Society of London.
Royal Asiatic Society.
Royal Geographical Society.
Royal Institution.
Royal United Service Institution.
Geological Society.
Linnean Society.
Zoological Society.
Photographic Society.
Philological Society.
Society of Arts.
British Meteorological Society.
British Association.
Art-Union of London.
Institute of Actuaries.
British Horological Institute.
Radcliffe Trustees.
Syndicate of Observatory, Cambridge.
Lancashire Historic Society.
Literary and Philosophical Society, Liverpool.
Literary and Philosophical Society, Leeds.
Literary and Philosophical Society at Manchester.
Royal Society of Edinburgh.
Royal Scottish Society of Arts.
Royal Irish Academy.
Royal Dublin Society.
Imperial Observatory, Paris.
Imperial Observatory, Vienna.
Royal Observatory, Munich.
Royal Observatory, Madrid.
Royal Observatory, Brussels.
Observatory, Coimbra.
Observatory, Dorpat.
Observatory, Harvard College.
United States Naval Observatory.
Magnetic Observatory, Toronto.
Collegio Romano.
L'Académie Impériale des Sciences de l'Institut de France.
Le Dépôt Général de la Marine.

Le Bureau des Longitudes.
Imperial Academy of Sciences, Vienna.
Royal Academy of Sciences, Berlin.
The Society of Physics, Berlin.
Royal Academy of Sciences, Brussels.
Royal Academy of Sciences, Göttingen.
Royal Academy of Sciences, Amsterdam.
Royal Society, Naples.
Royal Academy of Sciences, Sweden.
Royal Society of Sciences, Upsala.
Royal Academy of Sciences, Madrid.
Royal Academy of Sciences, Bologna.
Royal Academy of Sciences, Lisbon.
Royal Academy of Sciences, Turin.
Royal Institute of Lombardy.
Imperial Academy of Sciences, St. Petersburg.
Academy of Sciences, Batavia.
Academy of Sciences, Montpelier.
Austrian Board of Marine.
The Society of Sciences, Geneva.
The Society of Sciences, Zurich.
Canadian Institute.
American Academy of Arts and Sciences.
American Philosophical Society.
Smithsonian Institution.
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Editors of Silliman's Journal.
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Editor of the Critic.
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Editor of the Reader.
Editor of the Intellectual Observer.
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W. Adolph, Esq.
Asher and Co.
Lieut. Ashe.
Dr. Bache.
Dr. Beke.
L. S. Benson, Esq.
Prof. G. P. Bond.
E. W. Brayley, Esq.
H. Breen, Esq.
T. W. Burr, Esq.
R. C. Carrington, Esq.
E. H. Coleman, Esq.
M. Dollen.
S. M. Drach, Esq.
A. Escott, Esq.
M. Faye.
M. C. Flammarion.
C. Frodsham, Esq.
Dr. Galle.
J. Glaisher, Esq.
S. Gorton, Esq.
Prof. Grant.
M. Guillemin.
M. Gylden.

W. D. Haggard, Esq.
Prof. Hansen.
J. Hartnup, Esq.
Prof. Heis.
Prof. H. Hennessey.
J. Herapath, Esq.
Sir J. F. W. Herschel.
Alexander Herschel, Esq.
Dr. Kaiser.
Dr. Lee.
Dr. Mann.
J. R. Maclear, Esq.
Rev. W. Mitchell.
M. Möhn.
H. A. Newton, Esq.
Dr. Peters.
Prof. Plantamour.
M. Powalky.
Prof. Quetelet.
M. Radau.
Lord Rosse.
Sig. G. Santini.
M. Sawitch.
Prof. Secchi.
Major-Gen. Shortrede.
Admiral W. H. Smyth.
Prof. C. P. Smyth.
M. O. Struve.
G. V. Vernon, Esq.
Major Walker.
M. Weber.
M. Winnecke.
Prof. R. Wolf.

Address delivered by the President, Warren De La Rue, Esq., on Presenting the Gold Medal of the Society to Professor G. P. Bond.

Gentlemen,—When father and son have worked zealously together in the same direction, and especially in those cases where the son has succeeded to the position created and held for a number of years by the father, it is extremely difficult to draw any line of demarcation, from which to date the commencement of the son's independent career, or the cessation of the momentum imparted to his course of activity by the father. This is especially the case with respect to the late Professor W. C. Bond and his son, Professor George Phillips Bond, to whom the Council have awarded the highest mark of distinction this Society can confer.

In the estimate formed of his scientific work, the professional astronomer is generally placed somewhat at a disadvantage in comparison with the amateur. In the case of the latter, the whole of his work is weighed in the balance, while, in that of the former, large deductions are made from his labours as belonging properly to the duties of his official position. An official astronomer, in this age of zealous activity and speedy publication, inaugurated I believe by the example of the present Director of our own Royal Observatory, may, consequently, produce much good and original work without his name coming with due prominence before his peers, so long as that work falls, or rather appears to fall, within the range of his official duties. It is not my present purpose to explain the

reason of this, or to offer a justification of it, but merely to draw your attention to the fact. Fortunately, however, there frequently comes to the notice of men of science a proof that the devoted zeal which has marked the execution of what Englishmen designate with a wide signification as duty, has really carried the official astronomer beyond the conscientious fulfilment of his vocation, and induced him to devote his hours of leisure to extensive scientific work, which could not be included in the word "duty" with whatever latitude that expression might be employed.

Unquestionable evidence that Prof. G. P. Bond has done more for our science than even a scrupulous discharge of his duty demanded, was given by the appearance of the *Annals of the Astronomical Observatory of Harvard College*, vol. iii. 1862. At first sight, indeed, that volume might appear to be nothing beyond a record of excellent, but, nevertheless, official work: when, however, I shall presently come to speak of its details, it will, I doubt not, be conceded that it belongs in a great measure to the category of private labour independent of official duty.

The appearance of this publication induced your Council to review the work previously accomplished by Professor G. P. Bond, when it was found that he had been a most active contributor to astronomical discovery and methods for a long series of years, and that, besides his great, and I may say unique work on the Comet of 1858, an amount of good work had been accomplished by him which fully entitled him to the distinction this day conferred upon him.

Professor G. P. Bond, as you are aware, commenced his astronomical career as chief assistant to his father, Professor W. C. Bond; his earlier exertions appear to have been directed to the discovery of Comets and the computation of their orbits, and in the Report of the Committee of Harvard College he is mentioned as having detected independently eleven of those bodies. It is not surprising, therefore, that so zealous an observer of these strange visitors, about the nature of which so little is known, should have been one of the most assiduous observers of so splendid a Comet as that of Donati. It was also a natural consequence that Professor Bond should have desired to compare his own results with those of other observers, but it was by no means a necessary sequence that he should have entailed upon himself the enormous labour of collecting, systematically arranging, and reducing, the whole of the data resulting from this comparison.

The circumstances attending the apparition of the Comet of 1858 were peculiarly favourable; its early discovery by Dr. Donati, while yet a faint telescopic object, and the prediction of its great brilliancy and splendour, having had the effect of directing the attention of a great number of astronomers to this remarkable body. Hence, in the history of cometary

observations, there has never been collected so large a mass of observations as in the case of Donati's Comet; the absence of moonlight, the short duration of twilight, and the remarkable continuance of clear weather during the most important part of the Comet's apparition, largely contributing to this result. The darkness of the sky, which served as a background to the Comet, was peculiarly favourable to the delineation of the fainter outlines and peculiar features of this splendid visitor, which was visible to the naked eye from August 19th to December 9th, one hundred and twelve days. The whole period of visibility in the telescope extended from June 2nd, 1858, to March 4th, 1859, an interval of two hundred and seventy-five days. One of the most successful workers in recording the phenomena of this Comet was Professor G. P. Bond, and the sketches and drawings made at the Observatory of Harvard College form the main contribution to the splendid graphic illustrations which are a remarkable feature of this altogether remarkable production. The pains taken to ensure a truthful representation of this Comet of 1858, both in its eye- and telescope-features, few are better able than myself to appreciate; and I am able, from my own practical experience, to state that the success which has attended these efforts has been deservedly won by battling with greater difficulties than would probably be imagined by the uninitiated.

The comprehensiveness of Prof. Bond's work will be at once rendered evident by an enumeration of the various sections into which it is divided. They are as follows:—

I. Figure and Position of the Tail.
II. Observations upon the Secondary Tails.
III. Reduction of Observations upon the Figure and Position of the Tail.
IV. Probable Errors of Observations of the Tail.
V. On the Deflection of the Tail.
VI. Columnar Structure of the Tail.
VII. Reduction of Observations on the Secondary Tails.
VIII. The Nucleus and Envelopes.
IX. On the Outline of the Head of the Comet.
X. On the Branches and Central Darkness of the Tail.
XI. The Nucleus.
XII. The Envelopes.
XIII. The outer faint Veil.
XIV. On the Direction and Initial Axis of the Tail.
XV. Summary of the Contents of the Volume.

In the Introduction are given two diagrams, which much facilitate a proper appreciation of the description which follows, namely, the projection of the Earth's orbit on the Comet's orbit, and of the Comet's orbit on the Earth's orbit.

If I state the treatment of the naked-eye observations—including those made with telescopes of low power—it will enable the Society to form an opinion of the exhaustive method adopted by Professor Bond in discussing the phenomena presented by the Comet. Sections i. to vii. relate to the figure, dimensions, and positions of the tail, from its first appearance on the 14th of August, 1858, seventy-three days after its first discovery, when it was seen at Copenhagen by D'Arrest and at Vienna by Homstein, until the last recorded observation at Santiago, in Chili, by Moesta, on Feb. 7th, 1859. Arranged alphabetically under the same date, are the names of the several observers, sixty-seven in number, whose statements are given verbatim in the language in which they were written; but the value of this record is greatly enhanced by the occasional remarks of the author, who draws the reader's attention to points of special interest, and thus brings under notice the changes which actually occurred, as well as those which did not take place, although anticipated from previous hypotheses. The reader is informed, in the introductory chapter, that from the 2d of June to the 8th of September, the Earth was on the north side of the plane of the orbit, and on the latter day crossed the line of nodes, giving an opportunity for observations on the figure of the tail projected on a plane at right angles with the Comet's orbit. After the middle of September the tail was presented in nearly its full-length proportions; within a day or two of the perihelion passage on Sept. 30th, the axis of the tail was brought to a position at right angles to the line of vision, and, ten or twelve days later, when the Comet had reached its least distance from the Earth, its profile was almost precisely that of a section in the plane of its orbit. Professor Bond remarks that where so little is known, *à priori*, respecting the actual figure, there is an obvious advantage to be derived from these accidental circumstances of its position, by which the influence of perspective foreshortening is, in a great measure, eliminated. Throughout Section i. reference is occasionally made to the diagrams of the projection of the Earth's orbit on the Comet's orbit, and of the Comet's orbit on the Earth's orbit, so that no matter of interest is left unexplained which admits of elucidation by recalling the relative positions of the observer, the Sun, and the Comet. This chapter is illustrated with diagrams of the appearance of the tail as given by the several observers, and by most beautiful engravings of the aspect of the Comet as recorded at the Observatory of Harvard, the latter realising with a most extraordinary degree of perfection the delicately soft outline of that wonderful object, gradually vanishing, until it was lost on the dark background of the sky.

A special Section (ii.) is appropriated to observations of the secondary tail.

Section iii. is devoted to the reduction of the observations recorded in Sections i. and ii., and great acumen and industry are evinced by the author in dealing with the discrepancies necessarily existing in observations of this class. In order to recognise and explain any errors or ambiguities in the observations themselves, a provisional chart was constructed, showing the path of the Comet and the position of the tail among the neighbouring constellations. This chart naturally gave confidence and ensured accuracy in the subsequent discussion of the observations, which are duly "weighted" according to the dependence which can be placed upon them. In many cases the precise time of observation was not given, and, although in some of them it might be inferred from the context, yet in others it had to be supplied by considerations of the interval of visibility of the Comet, and means were found of doing this with but very small liability to any considerable error. The author also makes a remark which I fully endorse, that delineations of eye-observations, or such as are made with the aid of an opera-glass, would be much more reliable if they were drawn on star-charts. Lastly, the normal outlines of the tails are given in a series of charts which represent the final results deduced from the whole series of observations between September 16th and October 17th, referred to the common epoch for each date of 7^h mean solar time at the Observatory of Harvard College. The figure of the tail is preserved free from any considerable distortion by the method adopted; namely, by projection on a tangent cylinder, the position of which, in regard to the path of the Comet, was selected with that view.

The position of various points of the tail at certain distances from the nucleus are tabulated, and the probable errors of these positions discussed in Section iv. In this Section the positions given by the several observers are compared with the normal figures delineated in the charts before alluded to.

The same care and skill are evinced by Professor Bond in treating of the deflection of the tail, and in reducing the observations of the secondary tails which were noticed by several observers between the 27th of September and the 10th of October inclusive.

I think I have said enough to give you an idea of the comprehensiveness of the first seven Sections of Professor Bond's work on the Comet of 1858. Those parts which treat of the telescopic observations of the nucleus and envelopes are characterised by the same care, skill, and resource, but the difficulties of dealing with the discrepancies must have been enormously greater. These discrepancies no doubt arise in some measure from differences in the aperture and defining power of the telescopes employed; in other instances, much is attributable to the state of the atmosphere at the places of observation. The discordances arising from the foregoing causes

would, however, not present so many difficulties, were astronomers, as a rule, able to delineate what they see with any thing like an approach to accuracy of detail. Much confusion is created by the exaggeration of certain details which happen to strike forcibly the mind of particular observers, who give undue prominence to those features both as regards size and intensity. But astronomers are not responsible for the whole of the difficulties placed in the way of those who undertake the task of reducing observations; the steel-engraver, the lithographer, and the wood-engraver, are answerable for a great share of the confusion engendered by their very free translations of the drawings placed in their hands to be copied.

Professor Bond gives in his work a plate representing the drawings or engravings of the nucleus and envelopes in the form they reached him. A cursory inspection of this collection will suffice to show how great is the diversity of portraiture of the same object, even when made at about the same period of absolute time. The preparation of the volume was on that account, and from defective description, attended with considerable difficulty; so much so that a less zealous worker would have been deterred from prosecuting to its final completion his self-imposed task, the execution of which will redound in all time to the credit of the recipient of the Medal this day.

It would take me far beyond the limits of this Address were I to attempt to give you an intelligible summary of the various deductions obtained from the discussion of the telescopic appearances presented by the Comet. It will suffice to say that the monograph is characterised by a careful consideration of the geometrical conditions involved, and that there is no point of interest which has not received due attention on the part of the author, and that in the summary the whole results of his exhaustive investigation are placed before the reader in so concise and clear a manner that it would be a work of supererogation here to reproduce them.

I may mention, however, that the form of the head of the Comet received considerable attention, and that the result was such as to show that its outline did not accord with a parabola, but that, making due allowance for perspective foreshortening, its contour was nearly that of a catenary curve; moreover, that advantage was taken by the author of the apparition of Comet III., 1860, and, more recently, of the great Comet of 1861, to test some of the hypotheses discussed in reference to the Comet of 1858, notably the phenomena of the successive throwing off of a series of envelopes from the nucleus, and the diminution of their elevation velocities as they receded from it. A recent careful revision of these phenomena has, according to the Report of Professor Bond for 1864, completely confirmed the results previously announced.

Before dismissing the consideration of the volume on the Comet of 1858, I must add a few words in honour of Mr. Josiah

Quincy, of Boston, whose fund defrayed the expenses of the letter-press of that splendid work, and of the twenty-four gentlemen of Boston, Watertown, Cambridge, and Salem, who subscribed the sum necessary to cover the cost of the unrivalled engravings with which it is illustrated. It is most creditable to these gentlemen that they so fully appreciated the importance of doing ample justice to the labours of the Director of the Observatory of Harvard College, and enabled him to lay before the public such a written and graphic record as could not fail to attract the attention and obtain the confidence of the astronomical world. It should be remembered that the Observatory in question is not an institution endowed with ample funds to meet all its requirements, but that, on the contrary, appeals for aid to patriotic citizens have frequently been necessary, and have always been generously responded to, whenever any object of scientific importance could be thus advanced.

In the *Memoirs of the American Academy of Arts and Sciences*, vol. iii., are two papers by G. P. Bond. The first is "*An Account of the Nebula in Andromeda*,"* and was read before the Academy in March 1848; it will be recollected that the mounting of the great refractor was completed in July 1847, and the earliest opportunity was taken of turning it upon this interesting nebula which is visible to the naked eye, and the existence of which was recognised about 600 years before the invention of the telescope. It was expected that the great optical power of the instrument would establish its resolvability, but although this was not the case, several interesting features were discovered in the nebula and figured by Prof. Bond. The second paper is entitled "*Some Methods of Computing the Ratio of the Distances of a Comet from the Earth.*"† This paper must be considered to be a most useful addition to what had previously appeared on the subject of cometary calculations.

I have now to refer to a very important step made by Professor Bond in connexion with the theory of planetary perturbation. It is well known that when the excentricity and the inclination of the orbit of the disturbed planet are considerable, the problem of three bodies presents difficulties which have baffled the efforts of the most consummate mathematicians since the time of Newton. Fortunately, when the question relates to the computation of the perturbations of the principal bodies of the planetary system, such difficulties are not found to exist. In general, the planets revolve in orbits so nearly circular, and in planes inclined at angles so inconsiderable with respect to the ecliptic, that the problem of their perturbations admits of solution by a process of successive approximations, and results are obtained embodying general formulæ which enable us to compute numerically the deviations of the disturbed planet from

* P. 75. † P. 97.

its elliptic place corresponding to any assigned time, whether past or future. But, besides the minor planets, there is a whole class of bodies revolving round the Sun, whose orbits do not offer such facilities for the computation of their perturbations, but whose movements offer the highest interest to the physical astronomer. I allude to Comets, which revolve in orbits of every degree of excentricity and inclined to the ecliptic at angles of all degrees of magnitude. To compute the perturbations of such bodies, a special method has been devised, leading to results of a less comprehensive character than those derived from the general formulæ of planetary perturbation, but which enable us to assign the place of the disturbed body corresponding to a limited interval of time with any degree of accuracy which may be desired. This method, which is well known to astronomers as the method of Mechanical Quadratures, was first reduced to a complete system by Lagrange, and has since been applied with great success to the computation of the abnormal effects produced in the movements of Comets by the disturbing action of the more considerable bodies of the planetary system. It has also been applied in the present century to the computation of the perturbations of the minor planets, the excentricities and inclinations of whose orbits are in general of considerable magnitude. The chief merit of improving and applying this method of computation must, in all fairness, be assigned to our eminent Associate, Professor Encke, whose researches on the subject are to be found in the *Transactions of the Berlin Academy*, the volumes of the *Berlin Astronomisches Jahrbuch*, and the *Astronomische Nachrichten*. Nevertheless, after making this acknowledgment, I am bound to remark that Encke and other German Astronomers were to a very great extent anticipated by Professor G. P. Bond, whose suggestions were made so early as the month of May, 1849, in a paper entitled "*On some Applications of Mechanical Quadratures*," which was published in vol. iv. of the *Memoirs of the American Academy of Arts and Sciences;* whereas Encke's labours bear date from 1851, in which year he devised a process of computation founded on the same method of mechanical quadratures, and offering peculiar facilities for computing the perturbations of the minor planets. According to this method, the numerical values of the disturbing forces are calculated for any number of epochs, separated by moderately small and equal intervals of time. From these are deduced the corresponding rates of change of each of the six elements of the disturbed orbit, at the several epochs, and then, by the well-known pure mathematical process of integration by quadratures, the total changes in each of the elements produced in any number of the given intervals may be found.

Thus the altered elements of the orbit at any time become known, and from these again we deduce the co-ordinates of the

disturbed body, which are the quantities of which we are in search.

Now, with reference to this method, it may be remarked that, although it is a very beautiful one in theory, and leaves nothing to be desired as regards the accuracy of the results which are attainable by its means, it has the disadvantage of requiring the determination of double the number of unknown quantities that are really wanted. Also, in order to find the differentials of the elements, the values of the disturbing forces at each of the given epochs must be multiplied by variable quantities which are functions of the elements as well as of the co-ordinates of the disturbed body, and thus the calculations become excessively long. As these have to be gone through for each of the minor planets, it will be easily imagined that as more and more of these bodies were discovered the want of a readier method of computing their perturbations became more and more pressing.

Our eminent Associate, Professor Encke, to whom we owe the most complete and convenient mode of applying this method in practice, and who has probably made more extensive use of it than any other living man, was impelled by these considerations, to devise a mode of applying the method of integration by quadratures directly to the equations of motion of the disturbed body. In a paper on this subject, which was published in 1851 in the *Proceedings of the Berlin Academy* he refers the place of the body to rectangular co-ordinates, and determines the perturbations of its movements during successive short intervals of time, by a direct computation of the changes produced in the values of the three co-ordinates by the action of the disturbing planet. The differential equations of motion supply us at once with the values of the second differential coefficients of these quantities at any epoch, if we know the quantities themselves for that epoch, and also the magnitudes of the disturbing forces. Knowing these differential coefficients we can ascertain, by very simple calculations, the values of the disturbed quantities at the next epoch, and thus can continue the process to any extent that may be required.

At the time that Professor Encke communicated this memoir to the Berlin Academy, he was totally unaware that Professor Bond had been working at the same subject, and had communicated to the American Academy of Arts and Sciences, the paper before mentioned. In part of this paper, Professor Bond briefly but clearly explains a method of computing perturbations which is exactly similar to that of Professor Encke which has just been referred to. There are some unimportant differences in the details, and Professor Encke developes his method with somewhat greater fulness, but the two methods are essentially the same. Extensive use has already been made of this method of determining the perturbations of

the minor planets, and Professor Hansen has shown how to find by a similar method the perturbations of that system of co-ordinates which he considers it preferable to employ instead of the ordinary ones.

Although the method of integrating a differential equation of the second order by quadratures, cannot be said to be new in principle, for Euler has clearly expounded the theory of it in his invaluable *Institutiones Calculi Integralis*, and it may have been employed by other astronomers in special cases,* yet Professor Bond is entitled to the highest credit for having formed the idea of applying the method of mechanical quadratures to the solution of simultaneous differential equations, and for having been the first to publish a process, devised by himself, by which the method is rendered practically available in the calculation of the planetary perturbations.

In the *Reports of the Superintendent of the United States Coast Survey* for the years 1850–53, occur notices of the services of Professors W. C. Bond and G. P. Bond in determining, by exchange of chronometers, the differences of longitude between Cambridge, U.S., and Liverpool, as a basis for the charts of the coast, and for the general geodetic purposes of the country. The longitudes of all the American Observatories have been referred to that of Cambridge, by means of the electric telegraph, so that by the exertions of the Professors Bond the meridian of Cambridge has become the normal from which the longitudes of the American continent have been fixed in reference to Greenwich.

The Annals of the Astronomical Observatory of Harvard College, vol. ii. part i., were published in 1857, when that Observatory was under the direction of the father, W. C. Bond; it consists of a record of observations of the planet *Saturn* made with the great Equatoreal between the years 1847 and 1857. Of course, the chief merit of that elaborate treatise is due to W. C. Bond, but a reference to the initials of the various observers brings out prominently as those of a most active observer the letters G. P. B., which are the initials of the subject of this notice. These are attached to two very important series of observations connected with the physical history of that interesting planet, namely, in the first place, those which in 1848 led to his discovery of the Eighth Satellite *Hyperion*, independently of and simultaneously with Mr. Lassell; and in the second place, observations of a peculiar luminous appearance within the then so-called inner ring, associated with a dusky belt crossing the planet in such a

* I am informed by Professor Adams that a method, similar in principle, was employed by him in obtaining the results respecting the relative positions and motion of the two heads of Biela's comet, which are given in the *Monthly Notices* for April 1846. This, however, in no way lessens the credit due to Professor Bond in connection with this matter, which no one is more ready cordially to acknowledge than Professor Adams himself.

position that it could not be mistaken for the shadow of the bright rings on the ball, which shadow was seen at the same time in its proper place. I need scarcely say that it was the dusky ring of *Saturn* that was then for the first time noticed, though it was only subsequently recognised as such when, on Nov. 15, 1850, Mr. Tuttle, of the Harvard Observatory, suggested that the existence of a new ring of a dusky character would explain the phenomena. Mr. Dawes subsequently, namely, on the 25th and 29th of the same month, discovered this same dusky ring, independently, with a refractor by Merz, of $6\frac{1}{2}$ inches aperture.

I believe I am right in stating that the only orbit of *Hyperion* yet published was computed by Professor G. P. Bond, from his own observations. He has also published an analytical investigation of the question of the stability of *Saturn's* rings, in which he arrives at the unexpected conclusion that they are in a fluid state.*

Among other titles to our esteem for him as an astronomer must be mentioned his share in the adaptation of the great Refractor of Harvard College to the observation of very small stars in zones of declination, the first-fruits of the plan being a Catalogue of 5500 Stars near the Equator, forming vol. i. part ii. of the above-named "Annals," the observations having been made by himself and Mr. Tuttle.

This plan, it will be remembered, consists partly in recording, by the electric method, the times of transit of stars as they cross certain vertical lines drawn on a piece of transparent mica attached to the diaphragm of the spider-line micrometer. The electric recording apparatus is that originally contrived by the late W. C. Bond and his two sons, in which the movement of the recording barrel is regulated by their well-known spring-governor. On the piece of transparent mica exhibiting the transit lines, is also drawn a series of horizontal lines, $10''$ of declination apart, grouped into threes and sixes, to indicate half-minutes and minutes, the former denoted by making every third line somewhat longer than the adjoining ones, and the latter by causing every sixth line to extend quite across the slip of mica. By means of a cross-light illumination, the lines are made to appear white on a dark ground. "The observer, with the aid of an assistant, whose office it is to record the declinations, magnitudes, &c., has it in his power to give the elements of position and magnitude of each star at the rate of seven per minute; the average frequency of observations being only two in each minute." Since Professor G. P. Bond's appointment to the direction of Harvard Observatory in 1859 these Zone Observations have been diligently continued; and in his Report for 1864, it is stated that the

* Presented to the American Academy of Arts and Sciences, April 15th, 1851.

region between +1° 00′ and 1° 10′ has been nearly completed, and that great progress had been made in the zones between 1° 10′ and 1° 20′.

It is only necessary to read the Reports of the "Committee of the Overseers" of Harvard College, and the accompanying Reports by the Director of the Observatory, to show that the same zeal animates Professor G. P. Bond that was so strongly evinced by his father. The vast amount of work accomplished in the way of observation, reduction of the results, and their publication, is truly surprising, for we must in forming an estimate always bear in mind that the Observatory of Harvard College has very small means at its disposal, in comparison with the magnitude of its undertakings.

There is one claim to recognition which I, of all persons, must not pass over without notice; namely, the first application of Photography to Astronomical Observations,—for it was my seeing, in the Exhibition of 1851, a Lunar photograph which emanated from this Observatory, that stimulated me to undertake experiments in that direction. The first application of photography to the delineation of our satellite and of some of the fixed stars, I had attributed to Prof. W. C. Bond, in connexion with Messrs. Whipple and Black of Boston, but I am informed that it originated with G. P. Bond, to whom, therefore, in conjunction with these last-named gentlemen, the merit of this important step must be assigned.

Professor Bond's latest, and yet unfinished, work is that upon the Nebula of *Orion*, which object is also engaging the attention of Lord Rosse. Professor Bond has already sent to England a proof from a steel plate engraved from his drawing; he has catalogued the stars in and around the nebula with more minuteness than the Russian astronomers; and he has been so fortunate as to discover in the nebula a grand feature which has hitherto escaped the attention of astronomers. This new feature is a great re-entering loop of nebulous matter extending around nearly the whole of the previously known portion, and enclosing, as with a nebulous wall, a large space exterior to the well-known figure. It was discovered by employing, with the 22-feet refractor of 15 inches aperture, an eye-piece magnifying 90 times, with a field of 30′; by this arrangement it was seen with great distinctness. It is well known how clearly the low powers of comet-seekers bring out the faint details of comets; and the conversion, so to speak, of the Harvard Refractor into a huge comet-seeker has led to this interesting discovery.

In 1851 Prof. G. P. Bond visited Europe, and his reception at the principal astronomical establishments, and especially at the classical Observatory of Pulkowa, as detailed in the *Annals of Harvard College Observatory*, vol. i. part i.,* may perhaps be

* Appendix, pp. clviii–clx. inclusive.

regarded as evincing something more than the ordinary courteous welcome due to a stranger. In 1863 he again visited Europe, when I had the pleasure of making his acquaintance, and I am convinced that on this, as on the occasion of his previous visit, Professor G. P. Bond not only gained many personal friends, but also the high opinion and respect of those Astronomers with whom he came into contact.

The President then addressed the Foreign Secretary thus:—

Admiral Manners,—It has been my good fortune to visit the majority of European Observatories, and to make the acquaintance of their Directors and other gentlemen connected with them, and it has in consequence become known to me how high in their esteem our Foreign Secretary stands. Your urbanity and promptitude in carrying out our foreign business have indeed become proverbial. In asking you therefore, Sir, to transmit this Medal to our Associate Professor George P. Bond with our best wishes for the continuance of his distinguished career, I know that I am calling you to a duty which will be personally gratifying to you, and at the same time I feel that no one is better fitted than yourself to convey to him an adequate expression of the enthusiasm which the announcement of his name as the Medallist of the year has elicited from this assembly.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

Warren De La Rue, Esq. F.R.S.

Vice-Presidents:

Professor Adams, M.A. F.R.S.
G. B. Airy, Esq. M.A. F.R.S. Astronomer Royal.
R. C. Carrington, Esq. F.R.S.
Rev. Robert Main, M.A. F.R.S. Radcliffe Observer.

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

Secretaries:

Richard Hodgson, Esq.
Rev. Charles Pritchard, M.A. F.R.S.

Foreign Secretary:

Admiral R. H. Manners.

Council:

Professor Cayley, M.A. F.R.S.
Rev. Professor Challis, M.A. F.R.S.
Thomas Cooke, Esq.
James Glaisher, Esq. F.R.S.
John Russell Hind, Esq., F.R.S., Superintendent of the *Nautical Almanac*.
Rev. Frederick Howlett.
William Huggins, Esq.
John Lee, Esq. LL.D. F.R.S.
Major-Gen. Shortrede.
James Simms, Esq.
Edward J. Stone, Esq. M.A.
Lieut.-Col. A. Strange.

Appendix.

The following is the important communication from Mr. Lassell referred to in the account given of the Malta Observations in page 117.

Malta, Dec. 31st, 1864.

Dear Sir,—As the termination of my astronomical labours here approaches, and as some time must elapse before their results can be published, a short *resumé* of their character may perhaps be acceptable to the Society.

During the major part of my three years' residence, the planets have been observed whenever favourably situated, especially *Mars*, *Saturn*, *Uranus*, and *Neptune*. *Jupiter* and *Venus* have also been observed, but with less frequency and less important results.

Neptune has received especial attention, and observations of his satellite have been made on almost all suitable occasions. A series of measures also of his diameter (and that of *Uranus*) has been made with a double-image micrometer. A careful scrutiny of the neighbourhood of the planet has been made whenever atmospherical circumstances warranted it, with a view to the detection of any other satellite, but without leading even to the suspicion of one. The known satellite is so well seen, especially when more than 8 or 9 seconds central distance from the planet, even in bright moonlight and without any extraordinary atmospherical circumstances, that I have arrived at a firm conviction that the planet is attended by no other satellite which will bear comparison in magnitude with the known one—not greater certainly than *Dione* or *Rhea* among *Saturn's* satellites bears to *Titan*. It may, indeed, be possible that a faint satellite several minutes distant might exist, though I have no suspicion of one, and any one so situated would be very difficult to recognise among the numerous minute stars which a telescope so large as this generally reveals.

The same kind of observations has been made upon *Uranus* and his satellites without leading to the discovery of any additional ones. The two interior satellites discovered by me in 1851 (see *Monthly Notices*, vol. xi., page 248, and vol. xii., page 15), are *very much* fainter than the satellite of *Neptune*, or than *Oberon* or *Titania*, yet I have been able frequently to see them sufficiently to make a rough estimate of their places, even in brilliant moonlight, with the 4-foot Equatoreal. As I have, in the absence of the Moon and under the most favourable atmospherical circumstances, sought diligently for additional satellites without being able even to suspect any, aided, moreover, by the careful scrutiny of my friend and assistant Mr. Marth, I have the fullest conviction that the two first dis-

covered by Sir William Herschel in 1787, commonly known as the bright satellites, and these two, are all of which the existence has been in any way proved. I am also persuaded that, if any others exist, they must be sensibly fainter than the faintest of these, unless, as I have surmised in the case of *Neptune*, there may be an excentric remote satellite, of at least three or four months' period, which, in the crowded part of the sky where the planet now is, it would be very difficult to detect. Indeed, in observing the planet as now situated, we should be very frequently embarrassed in recognising the satellites by the presence of numerous minute stars, if we were not directed to their appropriate places by an Ephemeris previously prepared.

From all my experience in the examination of the satellites of this planet, I cannot escape the conclusion that Sir William Herschel's observations, and also some later ones of presumed satellites, must have really been of small stars, which, in any telescope large enough to show the true satellites, are seen to accompany them pretty frequently in most parts of the heavens.

I feel, therefore, tempted to express an opinion that it is high time that in all future treatises on astronomy the proper number of known satellites should be assigned to these two planets,—namely, to *Uranus* four, and to *Neptune* one. I notice that a beautifully illustrated and generally well-written popular *Treatise of Astronomy* has been recently published in France, which assigns to *Uranus eight* satellites and to *Neptune two*.

It may be worth remarking that in March next *Uranus* will be very nearly in the same position as when first discovered, just completing one sidereal period.

Especial attention has been given, as may be supposed, to the planet *Saturn* and his fainter and closer satellites; *Titan* and *Japetus*, as they can be equally well observed with smaller telescopes, have had less of our notice, but *Hyperion* and the nearest five have been very carefully looked after.

In observing the closest satellites, we have found the most accurate mode to be to note the *times* when they respectively reached elongations, preceding or following, equal to the distance of a tangent to the end of the ring from its minor axis. Occasionally, when circumstances permitted, an imaginary tangent to the half-projection of the ring, or the limb of the planet, was taken, instead of the outer edge of the ring. Experience in this mode of estimation has led to very great confidence in its accuracy, especially when the passage of the same satellite over the four points, *i.e.* over the tangent, north and south, preceding, and north and south, following, can be observed. I have no doubt whatever that these determinations give far more accurate results than can be obtained by more direct micrometrical measurement.

To make these observations with the smallest loss of time, it has been Mr. Marth's practice to compute an Ephemeris of the approximate times when these phenomena would happen; and in observing the times of these contacts, it would occasionally appear that the limit of inaccuracy did not exceed one minute of time. In addition to these elongations, the passages of the satellites over the apex of the ball, north or south, were observed when practicable.

Another important result has suggested itself during the practice of this method — that, if a sufficient series of observations could be made, more exact dimensions of the rings, as well as any excentricities which may exist in them, would probably be developed in the series. As many refracting telescopes of large aperture (eight or nine inches), and of admirable definition, now exist, I have thought some of the possessors of them might be induced to take up this work, for which such telescopes are, I think, quite competent, if the approximate times of these phenomena were given. I have, therefore, suggested to Mr. Marth the calculation of the enclosed Ephemeris for the next opposition of the planet, which I have the pleasure now to present to the Society.

The Ephemeris gives the distance, in semi-diameters of the ring, of the satellites from its minor axis, the letter *p*, of course, indicating preceding, and the letter *f*, following. The other co-ordinate need not be given, bearing in mind that if the motion be from *p* to *f*, the satellite passes on the north side of the major axis, and if from *f* to *p*, on the south side.

At the end of the Ephemeris is a short Table of the lengths of the apparent semi-minor axes of the orbits of the several satellites, in the same terms, for three epochs of the next year, from which it may be inferred how much, north or south, of the ring's transverse axis the satellite is, when it passes these imaginary tangents. It also will appear from this that *Rhea* passes already too far north and south for the most accurate estimate; but *Tethys* will be well situated, and, being generally somewhat brighter than *Dione*, is perhaps the most suitable. I may mention here that the period of *Mimas* which Mr. Marth had deduced from my old observations has required little alteration, the true sidereal period being $0^d{\cdot}9424240$, or $0^d\ 22^h\ 37^m\ 5^s{\cdot}43$.

It may be useful in observations for determining the dimensions of the rings to state that the times required for the satellites respectively to traverse the whole length of the ring are, for *Rhea* $9^h\ 2^m$, *Dione* $7^h\ 44^m$, *Tethys* $6^h\ 56^m$, *Enceladus* $6^h\ 23^m$, and for *Mimas* $5^h\ 57^m$.

It will be remarked that the interval between the epochs for each day in the Ephemeris is three hours: it would have been easy to have added an intermediate epoch, but it would have occupied much more space in printing. If, however, the Ephemeris should be found useful, and the Society desires it,

Mr. Marth will be happy to give it for shorter intervals, and also to carry it on for the remaining half of *Saturn's* opposition, if such a wish be intimated in time.

A series of drawings I have made of *Mars*,— *i. e.* of the phenomena of his surface, during and since his recent opposition, has been more interrupted than I should have thought possible in this climate, the weather during the last two months having been quite as unfavourable for observation as it usually is in England at the same season.

Another object I have not less anxiously pursued during my sojourn here, has been the delineation of the most conspicuous or remarkable planetary and other Nebulæ, of which I have made a good many drawings, including an elaborate one of the great Nebula in *Orion*, not yet finished. I have found great difficulty in some attempts I have made to get these drawings faithfully copied, and my want of complete success induces me to postpone until my return to England any further steps towards their publication.

All these objects being first satisfied, Mr. Marth has been very industriously scrutinising the heavens when the Moon was absent for new Nebulæ. In this portion of the work I have personally taken a very small share; and as it has been only pursued in the absence of other demands, it cannot be supposed that the scrutiny even of those parts of the heavens subjected to it can have been very perfect. A good many new Nebulæ have, however, been found, some description of which I hope to be able to give at a future time.

Ephemeris of the Five Inner Satellites of Saturn.

For 12th and 15th Gr. Sider. T.

1865.	Rhea.	Dione.	Tethys.	Enceladus.	Mimas.
Feb. 10	f. 3·87	p. 0·89	f. 0·76	f. 1·04	p. 1·19
	3·84	1·59	1·51	1·64	0·33
11	f. 0·88	p. 1·40	p. 1·10	p. 1·54	p. 0·88
	0·22	0·66	1·76	0·85	f. 0·17
12	p. 3·55	f. 2·73	f. 1·42	p. 0·61	p. 0·45
	3·76	2·46	1·96	1·40	f. 0·65
13	p. 2·18	p. 2·19	p. 1·68	f. 1·71	f. 0·04
	1·59	2·58	2·09	1·24	1·03
14	f. 2·75	f. 0·16	f. 1·90	f. 0·13	f. 0·52
	3·18	0·94	2·16	1·05	1·28
15	f. 3·18	f. 1·98	p. 2·05	p. 1.75	f. 0·93
	2·75	1·35	2·16	1·53	1·36
16	p. 1·59	p. 2·77	f. 2·14	f. 0·35	f. 1·22
	2·18	2·71	2·09	p. 0·63	1·27

1865.		Rhea.	Dione.	Tethys.	Enceladus.	Mimas.
Feb.	17	p. 3·76	f. 1·67	p. 2·17	f. 1·65	f. 1·36
		3·55	2·22	1·95	1·70	0·99
	18	f. 0·21	f. 0·57	f. 2·12	p. 0·81	f. 1·31
		0·88	p. 0·22	1·76	f. 0·16	0·60
	19	f. 3·84	p. 2·42	p. 2·00	p. 1·43	f. 1·08
		3·87	1·94	1·50	1·75	0·12
	20	f. 1·19	f. 2·61	f. 1·83	f. 1·21	f. 0·72
		0·54	2·77	1·21	0·33	p. 0·37
	21	p. 3·41	p. 1·02	p. 1·60	f. 1·09	f. 0·26
		3·67	1·71	0·87	1·65	p. 0·82
	22	p. 2·43	p. 1·26	f. 1·31	p. 1·51	p. 0·24
		1·88	0·52	0·51	0·78	1·15
	23	f. 2·53	f. 2·69	p. 0·98	p. 0·67	p. 0·70
		3·00	2·39	0·13	1·44	1·34
	24	f. 3·35	p. 2·28	f. 0·63	f. 1·69	p. 1·07
		2·97	2·63	p. 0·26	1·19	1·34
	25	p. 1·30	f. 0·31	p. 0·25	f. 0·20	p. 1·31
		1·91	1·08	f. 0·63	1·11	1·17
	26	p. 3·82	f. 1·87	p. 0·14	p. 1·75	p. 1·36
		3·66	1·23	0·99	1·49	0·85
	27	p. 0·09	p. 2·77	f. 0·51	f. 0·28	p. 1·23
		f. 0·58	2·68	1·32	p. 0·69	0·41
	28	f. 3·79	f. 1·79	p. 0·87	f. 1·67	p. 0·94
		3·87	2·31	1·60	1·68	f. 0·09
Mar.	1	f. 1·48	f. 0·36	f. 1·21	p. 0·74	p. 0·53
		0·83	p. 0·37	1·84	f. 0·23	f. 0·57
	2	p. 3·25	p. 2·34	p. 1·51	p. 1·47	p. 0·05
		3·57	1·82	2·01	1·75	f· 0·97
	3	p. 2·66	f. 2·66	f. 1·76	f. 1·15	f. 0·44
		2·14	2·77	2·12	0·25	1·25
	4	f. 2·28	p. 1·17	p. 1·96	f. 1·15	f. 0·88
		2·79	1·83	2·17	1·68	1·36
	5	f. 3·50	p. 1·12	f. 2·09	p. 1·47	f. 1·19
		3·15	0·36	2·15	0·71	1·30
		.1·02	f. 2·65	p. 2·16	p. 0·74	f. 1·35
		1·65	2·30	2·05	1·48	1·05
		p. 3·86	p. 2·37	f. 2·15	f. 1·67	f. 1·33
		3·75	2·68	1·89	1·12	0·67
	8	p. 0·39	f. 0·45	p. 2·09	f. 0·28	f. 1·13
		f. 0·28	1·22	1·67	1·17	0·20
	9	f. 3·72	f. 1·74	f. 1·95	p. 1·75	f. 0·78
		3·85	1·06	1·40	1·45	p. 0·30
	10	f. 1·74	p. 2·77	p. 1·75	f. 0·20	f. 0·33
		1·12	2·63	1·09	p. 0·77	p. 0·75

1865.		Rhea.	Dione.	Te'hys.	Enceladus.	Mimas.
Feb.	11	p. 3·09	f. 1·91	f. 1·49	f. 1·69	p. 0·17
		3·45	2·40	0·74	1·66	1·11
	12	p. 2·86	f. 0·25	p. 1·19	p. 0·66	p. 0·64
		2·38	p. 0·54	0·36	f. 0·31	1·32
	13	f. 2·05	p. 2·24	f. 0·85	p. 1·51	p. 1·03
		2·58	1·69	p. 0·02	1·75	1·35
	14	f. 3·61	f. 2·71	p. 0·49	f. 1·08	p. 1·28
		3·31	2·77	f. 0·41	0·17	1·20
	15	p. 0·50	p. 1·32	f. 0·11	f. 1·21	p. 1·36
		1·38	1·95	p. 0·78	1·70	0·90
	16	p. 3·87	p. 0·96	f. 0·28	p. 1·42	p. 1·27
		3·81	0·19	1·12	0·64	0·47
	17	p. 0·68	f. 2·59	p. 0·66	p. 0·81	p. 0·99
		0·01	2·20	1·43	1·52	f. 0·01
	18	f. 3.63	p. 2·45	f. 1·01	f. 1·64	p. 0·60
		3·81	2·70	1·70	1·06	f. 0·50
	19	f. 2·00	f. 0·64	p. 1·34	f. 0·36	p. 0·12
		1·40	1·38	1·91	1·23	f. 0·92
	20	p. 2·90	f. 1·61	f. 1·62	p. 1·75	f. 0·38
		3·30	0·90	2·06	1·40	1·22
	21	p. 3·05	p. 2·76	p. 1·86	f. 0·12	f. 0·82
		2·59	2·57	2·15	p. 0·84	1·36
	22	f. 1·80	f. 2·03	f. 2·02	f. 1·71	f. 1·15
		2·36	2·48	2·16	1·64	1·31
	23	f. 3·70	f. 0·03	p 2·13	p. 0·59	f. 1·34
		3·45	0·75	2·11	f. 0·39	1·09
Mar.	24	p. 0·45	p. 2·14	f. 2·17	p. 1·55	f. 1·34
		1·11	1·56	1·99	1·75	0·73
	25	p. 3·87	f. 2·74	p. 2·14	f. 1·02	f. 1·17
		3·85	2·75	1·81	0·08	0·27
	26	p. 0·95	p. 1·47	f. 2·03	f. 1·27	f. 0·84
		0·29	2·07	1·57	1·72	p. 0·23
	27	f. 3·52	p. 0·80	p. 1·87	p. 1·37	f. 0·40
		3·74	0·02	1·27	0·56	p. 0·70
	28	f. 2·24	f. 2·52	f. 1·65	p. 0·39	p. 0·10
		1·65	2·10	0·94	1·56	1·07
	29	p. 2·70	p. 2·53	p. 1·37	f. 1·61	p. 0·58
		3·14	2·75	0·58	0·99	1·30
	30	p. 3·21	f. 0·81	f. 1·05	f. 0·44	p. 0·98
		2·79	1·53	0·21	1·30	1·36
	31	f. 1·54	f. 1·46	p. 0·70	p. 1·74	p. 1·26
		2·13	0·74	f. 0·19	1·35	1·23
April	1	f. 3·77	p. 2·74	f. 0·33	f. 0·03	p. 1·36
		3·57	2·50	p. 0·56	p. 0·92	0·95

1865.	Rhea.	Dione.	Tethys.	Enceladus.	Mimas.
April 2	p. 0·17	f. 2·15	f. 0·06	f. 1·73	p. 1·29
	0·83	2·55	0·92	1·60	0·54
3	p. 3·83	p. 0·09	p. 0·45	p. 0·40	p. 1·04
	3·87	0·87	1·26	f. 0·48	0·05
4	p. 1·23	p. 2·02	f. 0·82	p. 1·59	p. 0·66
	0·57	1·41	1·55	1·74	f. 0·44
5	f. 3·40	f. 2·76	p. 1·16	f. 0·95	p. 0·18
	3·66	2·73	1·80	0·00	f. 0·87
6	f. 2·46	p. 1·62	f. 1·46	f. 1·33	f. 0·31
	1·91	2·19	1·98	1·74	1·19
7	p. 2·50	p. 0·63	p. 1·73	p. 1·31	f. 0·77
	2·98	f. 0·15	2·11	0·47	1·35
8	p. 3·36	f. 2·44	f. 1·93	p. 0·97	f. 1·12
	2·99	1·98	2·16	1·60	1·33
9	f. 1·28	p. 2·60	p. 2·07	f. 1·57	f. 1·32
	1·90	2·77	2·15	0·92	1·13
10	f. 3·83	f. 0·98	f. 2·15	f. 0·53	f. 1·35
	3·67	1·67	2·07	1·35	0·78
11	f. 0·11	f. 1·31	p. 2·16	p. 1·73	f. 1·19
	p. 0·56	0·56	1·92	1·29	0·33
12	p. 3·79	p. 2·70	f. 2·10	p. 0·06	f. 0·89
	3·87	2·45	1·71	1·00	p. 0·17
13	p. 1·49	f. 2·25	p. 1·97	f. 1·74	f. 0·46
	0·85	2·62	1·44	1·56	p. 0·64
14	f. 3·25	p. 0·27	f. 1·78	p. 0·41	p. 0·04
	3·56	1·04	1·14	f. 0·57	1·03
15	f. 2·66	p. 1·90	p. 1·54	p. 1·63	p. 0·52
	2·14	1·25	0·79	1·72	1·28
16	p. 2·29	f. 2·77	f. 1·24	f. 0·86	p. 0·93
	2·78	2·69	0·42	p. 0·09	1·36
17	p. 3·50	p. 1·76	p. 0·90	f. 1·39	p. 1·23
	3·15	2·29	0·04	1·75	1·27
18	f. 1·01	p. 0·45	f. 0·54	p. 1·25	p. 1·36
	1·65	f. 0·34	p. 0·35	0·38	0·99
19	f. 3·86	f. 2·35	p. 0·16	p. 1·04	p. 1·31
	3·74	1·85	f. 0·73	1·64	0·59
20	f. 0·39	p. 2·66	p. 0·23	f. 1·53	p. 1·08
	p. 0·28	2·77	1·07	0·83	0·12
21	p. 3·72	f. 1·14	f. 0·61	f. 0·62	p. 0·71
	3·85	1·81	1·39	1·41	f. 0·38
22	p. 1·74	f. 1·14	p. 0·96	p. 1·70	p. 0·25
	1·11	0·39	1·67	1·23	f. 0·82
23	f. 3·09	p. 2·66	f. 1·29	p. 0·15	f. 0·26
	3·45	2·32	1·89	1·07	1·16

1865.	Rhea.	Dione.	Tethys.	Enceladus.	Mimas.
April 24	f. 2·85	f. 2·35	p. 1·59	f. 1·75	f. 0·72
	2·06	2·68	2·04	1·52	1·34
25	p. 2·06	p. 0·45	f. 1·82	p. 0·33	f. 1·08
	2·59	1·20	2·14	f. 0·65	1·34
26	p. 3·60	p. 1·76	p. 2·00	p. 1·65	f. 1·31
	3·30	1·08	2·17	1·70	1·16
27	f. 0·75	f. 2·77	f. 2·12	f. 0·78	f. 1·36
	1·39	2·60	2·12	p. 0·18	0·83
28	f. 3·87	p. 1·90	p. 2·16	f. 1·44	f. 1·22
	3·81	2·39	2·01	1·75	0·39
29	f. 0·66	p 0·27	f. 2·14	p. 1·18	f. 0·93
	p. 0·01	f. 0·52	1·84	0·30	p. 0·11
30	p. 3·63	f. 2·25	p. 2·05	p. 1·11	f. 0·51
	3·81	1·71	1·60	1·66	p. 0·58

Table of Semi-Minor Axes of Apparent Orbits of the Satellites.

	March 1.	March 31.	April 30.
Rhea	1·06	1·02	0·97
Dione	0·76	0·73	0·69
Tethys	0·59	0·57	0·54
Enceladus	0·48	0·46	0·44
(Mimas	0·37	0·36	0·34 hidden)
Ball	0·39	0·39	5·39

Comet IV. 1864.

Discovered by Herr Bäcker, of Nauen, on the 15th December, 1864, when it was in R.A. 278°, Decl. −1°, with the brightness of a star of the seventh magnitude. The following elements, calculated by Stud. F. Peters from observations of Dec. 18 at Berlin, Dec. 23 at Vienna, and Dec. 28 at Altona, are given, *Ast. Nach.* No. 1508:—

$$T = 1864, \text{ Dec. } 22{\cdot}73365 \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \varpi &= 322\ 32\ 24 \\ \Omega &= 203\ 40\ 3 \end{aligned}\right\} \text{ App. Equinox, 1864, Dec. 23}$$

$$i = 48\ 39\ 27$$

$$\log q = 9{\cdot}883227$$

Motion direct.

The mean observation is thus represented:—

$$C-O \qquad \Delta\lambda = +\ 14'' \qquad \Delta\beta = +\ 32''$$

Comet V. 1864.

Discovered by Prof. Bruhns, at Leipzig, on the morning of 30th Dec. 1864, the first observation being

1864, Dec. 30, $18^h\ 26^m\ 43^s$ Leipzig M.T.,
R.A. $= 14^h\ 1^m\ 52^s{\cdot}78$, Decl. $= 13°\ 6'\ 14''{\cdot}7$.

The following elements, calculated by him from the foregoing observations and those of the 2d and 3d Jan. 1865, are given, *Ast. Nach.* No. 1511:—

T = 1864, Dec. 27·36241 Berlin M.T.
π = 164 21 56·1
Ω = 342 26 11·1 } App. Equinox
i = 18 14 40·6
$\log q$ = 0·056220
Motion retrograde.

The mean observation is thus represented:—

C − O $\quad \Delta\lambda = +4''{\cdot}2 \quad \Delta\beta = +0''{\cdot}3$

It is, however, stated that the elements are somewhat uncertain, and two other slightly different sets are given, calculated by Stud. Valentiner and Dr. Engelmann respectively.

For Sale.

Large Object-Glass.—To be sold, the large Achromatic Object-Glass of sixteen inches aperture, made by Messrs. Troughton and Simms, in brass cell, with springs and adjusting screws. The materials—crown and flint glass—are very pure, and were made by Messrs. Chance, of Birmingham.—For particulars apply to Mr. Williams, Royal Astronomical Society, Somerset House, London.

Telescope, which belonged to the late Capt. W. S. Jacob, and was taken by him to Bombay in 1862, for the purpose of establishing an Observatory at Poona, under the auspices of the Royal Astronomical Society; but, owing to his death, was never used. The telescope was made by Messrs. Cooke and Sons, of York, under the immediate direction of Capt. Jacob.

Description.—A telescope of 9-in. aperture, 10-feet focal length, equatorially mounted, and made universal in its adjustments of latitude. Driving clock, set of eye-pieces, sun-prism, &c., four sun-glasses, in mahogany box, complete, position-

circle, large micrometer with eye-pieces with achromatic lenses, and mahogany box, small micrometer with two eye-pieces, adapting-tube, and mahogany box, double-bar micrometer, dynameter, wrought-iron pillar, screw, &c. Also, a radiation instrument and a chronometer. For price and further particulars apply to Rev. Dr. Jacob, Christ's Hospital, London. The telescope may be seen at Messrs. Cooke and Sons, Southampton Street, Strand.

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It is with regret that the Editor has to make the announcement contained in the following letter:—

To the President of the Royal Astronomical Society.

I regret to state that Prof. G. P. Bond departed this life last Friday morning (February 17th), at 9 o'clock, after very severe and prolonged suffering.

I fear his death will cause a void in astronomical science, especially in America, which it will be found hard to fill.

TRUMAN HENRY SAFFORD,
Assistant Observer, Harvard College Observatory.

Cambridge, Mass., U.S. Feb. 20, 1865.

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